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ABSTRACT

The Rate Training Manual and Nonresident Career Course (RTM/NRCC) form a self-study package that enables Construction Mechanics to fulfill the requirements for advancement to Construction Mechanic First Class (CM1) or Chief Construction Mechanic (CMC). Chapter 1 provides information relevant to the duties and responsibilities of a CM1 or CMC. Chapters 2-9 cover the following topics: supervision, public works transportation shops supervisor, battalion equipment company shops supervisor, engine overhaul, automotive electrical systems and equipment, diesel fuel systems, vehicle safety inspections, and power trains. Photographs and diagrams illustrate the document. A subject index, a list of the minimum qualifications for advancement to Construction Mechanic First Class and Chief Petty Officer, and a 54-page course assignment booklet for the nonresident career course conclude the document. (Author/BP)

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NAVAL EDUCATION AND TRAINING COMMAND

RATE TRAINING MANUAL AND NONRESIDENT CAREER COURSE

NAVEDTRA 10645-E

PREFACE

The ultimate purpose of training Naval personnel is to produce a combatant Navy which can ensure victory at sea. A consequence of the quality of training given them is their superior state of readiness. Its result is a victorious Navy.

This Rate Training Manual and Nonresident Career Course (RTM/NRCC) form a self-study package that will enable ambitious Construction Mechanics to help themselves fulfill the requirements of their rating. Among these requirements are the abilities to maintain, repair, and overhaul automotive, materials-handling, and construction equipment; to supervisor assistants who locate, analyze, and correct malfunctions of the equipment, and who issue repair parts; to maintain records and prepare requisitions and reports; and to train assistants in repair procedures and techniques.

Designed for individual study and not formal classroom instruction, the RTM provides subject matter that relates directly to the occupational qualifications of the Construction Mechanic rating. The NRCC provides the usual way of satisfying the requirements for completing the RTM. The set of assignments in the NRCC includes learning objectives and supporting items designed to lead students through the RTM. The NRCC is designated a major revision, and retirement point credit will be granted to Naval Reservists who complete (or retake) it successfully.

This training manual and nonresident career course was prepared by the Naval Education and Training Program Development Center, Pensacola, Florida, for the Chief of Naval Education and Training. Technical assistance was provided by the Naval Facilities Engineering Command, the Naval Construction Training Center, Port Hueneme, California; and the Naval Construction Training Center, Gulfport, Mississippi.

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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Nonresident Career Course follows Qualification for Advancement

CREDITS

The illustrations listed below are included in this edition of Construction Mechanic 1 & C through the courtesy of the designated source. Permission to use these illustrations is gratefully acknowledged. Permission to reproduce illustrations and other materials in this publication must be obtained from the source.

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CHAPTER 1

DUTIES AND RESPONSIBILITIES

If the Navy, as a team, is to achieve its ultimate goal of "Victory at Sea," each member of the team must be well trained and completely informed as to his duties and responsibilities. It is also essential that each member ensure that he constantly keeps himself informed as to any new developments that affect his rating.

This training manual is designed to help you meet the occupational qualifications for advancement to Construction Mechanic First Class and Chief Construction Mechanic. Chapters 2 through 9 of this training manual deal with the technical subject matter of the Construction Mechanic rating. The present chapter provides information that will help you in your duties and responsibilities as a CM1 or CMC. It is strongly recommended that you study this chapter carefully before beginning intensive study of the chapters that follow.

REWARDS AND RESPONSIBILITIES

Advancement brings both increased rewards and increased responsibilities. The time to start looking ahead and considering the rewards and the responsibilities of advancement is right now, while you are preparing for advancement to CM1 or CMC.

By this time you have probably discovered that one of the most enduring rewards of advancement is the personal satisfaction you find in developing your skills and increasing your knowledge. The Navy benefits by your advancement in that highly trained personnel are essential to the proper functioning of the Navy. With each advancement you increase your value to the Navy in two ways: First, you become more valuable as a technical specialist; and second, you become more valuable as a supervisor, leader, and instructor.

In large measure, the extent of your contribution to the Navy depends upon your willingness and ability to accept increasing responsibilities as you advance. When you assumed the duties of a CM3, you began to accept a certain amount of responsibility for the work of others. With each advancement, you accept an increasing amount of responsibility in military matters as well as technical responsibilities of the Construction Mechanic rating.

You will find that your responsibilities for military leadership are the same as those of a petty officer in other ratings, since every petty officer is a leader as well as a technical specialist. Your responsibilities for technical leadership are unique to your rating. The maintenance and repair of automotive and construction equipment is a job of vital importance.

Certain practical details that relate to your responsibilities for administration and supervision are discussed in other chapters of this training manual. At this point, let's consider some of the broader aspects of your increasing responsibilities for military and technical leadership.

YOUR RESPONSIBILITIES WILL EXTEND BOTH UPWARD AND DOWNWARD. Both officers and enlisted personnel will expect you to translate the general orders given by officers into detailed, practical on-the-job language that can be understood and followed even by relatively inexperienced personnel. In dealing with your juniors, it is up to you to see that they perform their work properly. At the same time, you must be able to explain to officers any important needs or problems of the enlisted men.

YOU WILL HAVE REGULAR AND CONTINUING RESPONSIBILITIES FOR TRAINING. Even if you are lucky enough to have a highly skilled and well trained group of mechanics, you will

still find that training is necessary. For example, you will always be responsible for training lower rated men to assume added responsibilities. Also, some of your best workers may be transferred and inexperienced or poorly trained personnel may be assigned to you. Or a particular job may call for skills that none of your personnel have acquired. These and similar problems require you to be a training specialist who can conduct formal and informal training programs to qualify personnel to perform more advanced technical assignments and who can train individuals and groups in the effective execution of assigned tasks.

YOU WILL HAVE INCREASING RESPONSIBILITIES FOR WORKING WITH OTHERS. As you advance to CM1 and then to CMC, you will find that some of your plans and decisions affect a large number of persons. It becomes increasingly important, therefore, to understand the duties and responsibilities of others.

Every petty officer in the Navy is a technical specialist in his own field. Learn as much as you can about the work of other ratings, and plan your own work so that it will fit in with the overall mission of the organization.

AS YOUR RESPONSIBILITIES INCREASE, YOUR ABILITY TO COMMUNICATE CLEARLY AND EFFECTIVELY MUST ALSO INCREASE. The basic requirement for effective communication is a knowledge of your own language. Use correct language in speaking and in writing. Remember that the basic purpose of all communication is understanding. To lead, supervise, and train others, you must be able to speak and write in such a way that others can understand exactly what you mean.

A second requirement for effective communication in the Navy is a sound knowledge of the Navy way of saying things. Some Navy terms have been standardized for the purpose of ensuring efficient communication. When a situation calls for the use of standard Navy terminology, use it.

Still another requirement of effective communication is precision in the use of technical terms. A command of the technical language of the Mechanic rating will enable you to receive and convey information accurately and to exchange ideas with others. A person who does not understand the precise meaning of terms used in connection with the work of his own rating is at a disadvantage when he tries to read official publications relating to his work. He is also at a great disadvantage when he takes the written examinations for advancement. Although it is always important for you to use technical terms correctly, it is particularly important when you are dealing with lower rated men. Sloppiness in the use of technical terms is likely to be very confusing to an inexperienced man. From time to time, inexperienced men under your supervision may ask you to explain the meaning of various terms used in the mechanic trade. Some of the terms which you may be asked to explain are listed and defined below; make sure you are familiar with the meaning of these and other technical terms you may encounter in your work.

Adjust: Use precision measuring devices to measure clearances; make operational adjustments.

Engine Overhaul (Minor); Perform cylinder head and valve overhaul; remove oil pan, refit main bearings, connecting rod bearings, and piston rings as necessary; renew piston rings; hone cylinder walls or renew cylinder liners as required; reassemble and make necessary adjustment for operation.

Engine Overhaul (Major): Completely disassemble engine; recondition or replace all component parts as required; rebore cylinders if required; reassemble, adjust, and test for operation.

Engine Tune-Up (Minor): Clean or renew spark plugs, renew ignition points and condenser, set ignition timing, set carburetor idle mixture and idle speed; service carburetor air cleaners; clean or renew fuel bowl filter or screen.

Engine Tune-Up (Major): Check engine transmission, clean or renew and adjust spark plugs; test battery, clean terminals; renew and adjust distributor points and condenser, check distributor cap and rotor; set ignition timing, test coil; free-up manifold head control valve; tighten cylinder head and manifold bolts; adjust carburetor idle speed; inspect and tighten all hose connections; adjust fan belt and solid valve tappets.

Minor Repair: Replacement of worn or broken parts and adjustments required to restore equipment (or facilities) to its original capability, not requiring a high degree of technical skill.

Operators/Watchstanders Maintenance: The required inspection, service, lubrication, and adjustments performed by an operator/watchstander to keep power tools and equipment in a safe operable condition, in order to prevent personnel injuries, mechanical malfunctions, and curtailment of production or progress.

Test: Use instruments or operate to identify possible malfunction or failure; or determine correctness of completed repair work.

YOU WILL HAVE INCREASED RESPONSIBILITIES FOR KEEPING UP WITH NEW DEVELOPMENTS. Practically everything in the Navy—policies, procedures, equipment, publications, and systems—is subject to change and development. As a CM1, and even more as a CMC, you must keep yourself informed about all changes and new developments that might affect your rating or your work.

There are several ways in which Navy training is changing. For instance, it is becoming more individualized because of the programmed instruction courses and audiovisual courses that are being introduced. These courses enable a trainee to choose his medium of instruction (manuals, tapes, programmed instruction, TV) and to proceed at his own pace (called self-pacing). Other changes you will see taking place in Navy training affect the development of instructional materials. One change calls for the use of job-related training materials. These are materials designed to teach trainees to do the tasks that constitute a job. Another change concerns the application of techniques and procedures for instructional systems development. In other words, Navy training will be based on analysis of job information and learning requirements from which tests, learning objectives, and training materials are developed.

Then too, you will find that in many ratings there are plans to train men and women from the time they enter the Navy until they retire. According to these plans, all training is put to use and overtraining is eliminated. The time devoted to instruction in many, if not all, class A schools will be shortened; also, the number of other schools will be reduced. As a consequence of shorter school terms and fewer schools, more training will take place onboard. This will result in the development of training packages to assist the onboard trainers. Many of these are sure to be multimedia packages, that is, use more than one medium of instruction.

Some changes will be called directly to your attention, but others you will have to look for. Try to develop a special kind of alertness for new information. Keep up to date on all available sources of technical information. And make a continuing effort to keep up to date on the subject of diesel and gasoline engines, automotive electrical systems, maintenance procedures, and so on, as well as changes or new developments in tools or equipment related to your job.

THE CONSTRUCTION MECHANIC RATING

Construction Mechanics schedule, oversee, and perform tasks involved in maintenance, repair, and overhaul of automotive, materials-handling, and construction equipment; assign and supervise activities of assistants who locate, analyze, and correct malfunctions in equipment, and issue repair parts; maintain records, prepare requisitions and reports; and train assistants in repair procedures and techniques.

Most of the billets for CM1 and CMC are allotted to mobile construction battalions, construction battalion units, and Public Works Departments. In a battalion, a CM1 or CMC usually serves as a supervisor of the equipment company shops. In a Public Works Department, the CM may serve as supervisor of the Transportation Shops. Other billets for CMs include recruiting duty, recruit training, and Naval Reserve training. A limited number of particularly well qualified CMs are also given assignments to instruct in Navy schools; to assist in making up the service-wide advancement examinations; to assist in the preparation of Rate Training Manuals (like this one); to serve as a member of a SEABEE team; and to perform other highly specialized duties where their technical knowledge can be utilized effectively for the needs of the service.

REQUIREMENTS FOR ADVANCEMENT

In general, to qualify for advancement you must:

1. Have a certain amount of time in rate.
2. Complete the required military and occupational training courses.
3. Demonstrate the ability to perform all the PRACTICAL requirements for advancement by completing the "Record of Practical Factors," NAVEDTRA 1414/1 CM.

4. Be recommended by your commanding officer.

5. Demonstrate your KNOWLEDGE by passing a written examination based on (a) the military requirements for advancement and (b) the occupational qualifications for advancement.

Remember that the requirements for advancement may change from time to time. Check with your division officer or with your training officer to be sure you have the most recent requirements when you are preparing for advancement and when you are helping lower rated men to prepare for advancement.

To prepare for advancement, you need to be familiar with (1) the military requirements and the occupational qualifications given in the Manual of Qualifications for Advancement, NAVPERS 18068-C; (2) the Record of Practical Factors, NAVEDTRA 1414/1 CM; (3) appropriate Rate Training Manuals; and (4) any other material that may be required or recommended in the current edition of Bibliography for Advancement Study, NAVEDTRA 10052. These materials are discussed later in the section of this chapter that deals with sources of information.

SCOPE OF THIS TRAINING MANUAL

Before studying any book, it is a good idea to know the purpose and the scope of the book. Here are some things you should know about this training manual:

- It is designed to give you information on the occupational qualifications for advancement to CM1 and CMC.

- It must be satisfactorily completed before you can advance to CM1 or CMC, whether you are in the regular Navy or in the Naval Reserve.

- It is NOT designed to give you information on the military requirements for advancement to PO1 or CPO. Rate Training Manuals that are specially prepared to give information on the military requirements are discussed in the section of this chapter that deals with sources of information.

- It is NOT designed to give you information that is related primarily to the qualifications for advancement to CM3 and CM2. Such information is given in Construction Mechanic 3 & 2, NAVPERS 10644-F.

- The occupational Construction Mechanic qualifications that were used as a guide in the preparation of this training manual were those promulgated in the Manual of Qualifications for Advancement, NAVPERS 18068-C.

Since your main purpose in studying this training manual is to meet the qualifications for advancement to CM1 or CMC, it is important for you to obtain and study a set of the most recent Construction Mechanic qualifications.

- This training manual includes information that is related to both the KNOWLEDGE FACTORS and the PRACTICAL FACTORS of the qualifications for advancement to CM1 and CMC. However, no training manual can take the place of actual on-the-job experience for developing skill in the practical factors. The training manual can help you understand some of the whys and wherefores, but you must combine knowledge with practical experience before you can develop the required skills. The "Record of Practical Factors," NAVEDTRA 1414/1 CM, should be utilized in conjunction with this training manual whenever possible.

- Before going on to the next chapter of this training manual, study the table of contents and note the arrangement of information. Information can be organized and presented in many different ways. You will find it helpful to get an overall view of the organization of this training manual before you start to study it.

SOURCES OF INFORMATION

It is very important for you to have an extensive knowledge of the references to consult for detailed, authoritative, up-to-date information on all subjects related to the military requirements and to the occupational qualifications of the Construction Mechanic rating.

Some of the publications discussed here are subject to change or revision from time to time — some at regular intervals, others as the need arises. When using any publication that is subject to change or revision, be sure you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been entered.

Official publications and directives carry abbreviations and numbers which identify the source of the document and its subject matter. An abbreviation designates the originator (for example, NAVEDTRA or NAVFAC), and the numbers that follow indicate the subject matter. A letter following the numbers designates the edition.

As a result of the establishment of the Naval Education and Training Program Development Center, new editions of rate training manuals, nonresident career courses, curricula, and other training publications formally designated with the abbreviation NAVPERS are being designated with NAVEDTRA. The numbers and the edition designators remain unchanged. This training manual, for instance, is NAVEDTRA 10645-E, which means that it is a publication of the Naval Education and Training Program Development Center.

In this chapter and elsewhere in this text, training publications which carry the new abbreviation are so listed; those not yet changed are listed as NAVPERS numbers. Always make sure that you are using the latest edition of any publication or directive.

NAVPERS AND NAVEDTRA PUBLICATIONS

The NAVPERS and NAVEDTRA publications described here include some of which are absolutely essential for anyone seeking advancement and some which, although not essential, are extremely helpful.

THE QUALS MANUAL.—The Manual of Qualifications for Advancement, NAVPERS 18068-C, gives the minimum requirements for advancement to each rate within each rating. The Quals Manual lists the military requirements which apply to all ratings and the occupational qualifications that are specific to each rating.

The Quals Manual is kept current by means of numbered changes. These changes are issued more frequently than most Rate Training Manuals can be revised; therefore, the training manuals cannot always reflect the latest qualifications for advancement. When preparing for advancement, you should always check the LATEST Quals Manual and the LATEST changes to be sure that you know the current requirements for advancement.

When studying the qualifications for advancement, remember these three things:

1. The quals are the MINIMUM requirements for advancement to each rate within each rating. If you study more than the required minimum, you will of course have a great advantage when you take the written examination for advancement.

2. Each qual has a designated pay grade—E-4, E-5, E-6, E-7, E-8, or E-9. You are responsible for meeting all quals specified for advancement to the pay grade to which you are seeking advancement AND all quals specified for lower pay grades.

3. The written examinations for advancement to E-6 and above contain questions relating to the practical factors and the knowledge factors of BOTH military/leadership requirements and occupational qualifications. Personnel preparing for advancement to E-4, or E-5 must pass a separate military/leadership examination prior to participation in the Navy-wide occupational examination. The military/leadership examinations for the E-4 and E-5 levels are given according to a schedule prescribed by the commanding officer. Candidates are required to pass the applicable military/leadership examination only once.

RECORD OF PRACTICAL FACTORS.—A special form known as the "Record of Practical Factors," NAVEDTRA 1414/1 CM, is used to record the satisfactory completion of the practical factors, both military and occupational, listed in the Quals Manual. Whenever a person demonstrates his ability to perform a practical factor, appropriate entries must be made in the DATE and INITIALS column. As a CMI or CMC, you will often be required to check the practical factor performance of lower rated men and to report the results to your supervising officer. To facilitate record keeping, group records of practical factors are often maintained by each activity. Entries from the group records must, of course, be transferred to each individual's Record of Practical Factors at appropriate intervals.

As changes are made periodically to the Quals Manual, new forms of NAVEDTRA 1414/1 are provided when necessary. Extra space is allowed on the Record of Practical Factors for entering additional practical factors as they are published in changes to the Quals Manual. The Record of Practical Factors also provides space for recording demonstrated proficiency in skills which are within the general scope of the rating but

which are not identified as minimum qualifications for advancement. Keep this in mind when you are training and supervising lower rated personnel. If a man demonstrates proficiency in some skill which is not listed in the Construction Mechanic quals but which falls within the general scope of the rating, report this fact to the supervising officer so that an appropriate entry can be made.

The Record of Practical Factors should be kept in each man's service record and should be forwarded with the service record to the next duty station. Each man should also keep a copy of the record for his own use. It is advisable for each individual to review his service record, approximately 15 days prior to any type of transfer, to ensure that his practical factor sheet and other important papers have been included in his record.

NAVEDTRA 10052.—Bibliography for Advancement Study, NAVEDTRA 10052, is a very important publication for anyone preparing for advancement. This publication lists required and recommended Rate Training Manuals and other reference material to be used by personnel working for advancement. NAVEDTRA 10052 is revised and issued once each year by the Naval Education and Training Program Development Center. Each revised edition is identified by a letter following its number. When using this publication, be SURE you have the most recent edition.

The required and recommended references are listed by rate level in NAVEDTRA 10052. It is important to remember that you are responsible for all references at lower levels, as well as those listed for the rate to which you are seeking advancement.

Rate Training Manuals that are marked with an asterisk (*) in NAVEDTRA 10052 are MANDATORY at the indicated rate levels. A mandatory training manual may be completed by (1) passing the appropriate Nonresident Career Course based on the mandatory training manual, (2) passing locally prepared tests based on the information given in the mandatory training manual, or (3) in some cases, successfully completing an appropriate Navy school.

It is important to notice that all references, whether mandatory or recommended, listed in NAVEDTRA 10052 may be used as source material for the written examinations, at the appropriate rate levels.

RATE TRAINING MANUALS.—Rate Training Manuals are written for the purpose of helping personnel prepare for assuming greater responsibilities and technical knowledge. In addition, the manuals are of great assistance in preparing for advancement. Some manuals are general in nature and are intended for use by more than one rating; others (such as this one) are specific to a particular rating.

Rate Training Manuals are revised from time to time to bring them up to date. The revision of a Rate Training Manual is identified by a letter following the NAVPERS/NAVEDTRA number. You can tell whether a Rate Training Manual is the latest edition by checking the NAVPERS/NAVEDTRA number and the letter following the number in the most recent edition of the List of Training Manuals and Correspondence Courses, NAVEDTRA 10061 (revised).

There are three Rate Training Manuals that are specially prepared to present information on the military requirements for advancement. These manuals are:

Basic Military Requirements, NAVPERS 10054 (current edition).
Military Requirements for Petty Officer 3 & 2, NAVPERS 10056 (current edition).
Military Requirements for Petty Officer 1 & C, NAVPERS 10057 (current edition).

Each of the military requirements manuals is mandatory at the indicated rate levels. In addition to giving information on the military requirements, these three manuals give a good deal of useful information on the enlisted rating structure; how to prepare for advancement; how to supervise, train, and lead other men; and how to meet your increasing responsibilities as you advance.

Some of the Rate Training Manuals that may be useful to you when you are preparing to meet the occupational qualifications for advancement to CM1 and CMC are discussed briefly in the following paragraphs. For a complete listing of Rate Training Manuals, consult the List of Training Manuals and Correspondence Courses, NAVEDTRA 10061 (revised).

Tools and Their Uses, NAVPERS 10085 (current edition). Although this training manual is not specifically required for advancement, you will find that it contains a wealth of useful information on the care and use of various types of handtools and portable power tools commonly used in the Navy.

Blueprint Reading and Sketching, NAVPERS 10077 (current edition). This training manual contains information that may be of value to you as you prepare for advancement to CM1 and CMC.

Applied Mathematics for Mechanics, NAVPERS 94418. This workbook when used in conjunction with the text, General Mathematics for Construction Ratings (NAVPERS 94415), forms a course of programmed instruction that is designed to help you learn the mathematics involved in the mechanic rating.

Construction Mechanic 3 & 2, NAVPERS 10644-F. Satisfactory completion of this training manual is required for advancement to CM3 and CM2. If you have met this requirement by satisfactorily completing an earlier edition of Construction Mechanic 3 & 2, you should at least glance through the-F revision of the training manual. Much of the information given in this edition of Construction Mechanic 1 & C is based on the assumption that you are familiar with the contents of Construction Mechanic 3 & 2, NAVPERS 10644-F.

SEABEE Combat Handbook, NAVTRA 10479. Some of the information contained in this manual will pertain to all the enlisted pay grades and some will apply to the higher pay grades (Petty Officer 1 and C), The information applying to Petty Officer 1 and C will be identified as such. However, even if you are a CM2 or CM1 you should read all of it because it will help you to better understand your place in a combat organization and why certain things will be required of you.

Rate Training Manuals prepared for other Group VIII (Construction) ratings are often a useful source of information. Reference to these training manuals will increase your knowledge of the duties and skills of other men in the Construction ratings. The training manuals prepared for Equipment Operators are likely to be of particular interest to you.

NONRESIDENT CAREER COURSES.—Completion of a mandatory training manual can be accomplished by passing the nonresident career course that is based on the training manual. Taking a nonresident career course helps you to master the information given in the training manual and also gives you a pretty good idea of how much you have learned from studying the manual. You will find it helpful to take other courses, as well as those that are based on the mandatory training manuals. Both NRCC and officer correspondence courses are listed in the List of Training Manuals and Correspondence Courses, NAVEDTRA 10061 (revised).

NAVFAC PUBLICATIONS

A number of publications issued by the Naval Facilities Engineering Command (NAVFAC) which will be of interest to personnel in the Group VIII ratings are listed in the Index of Naval Facilities Engineering Command Publications, NAVFAC P-349 (updated semiannually). A publications program is one of the principal communications media used by NAVFAC to provide a ready reference of current technical and administrative data for use by its subordinate units. NAVFAC publications are listed in alphabetical and numerical order in NAVFAC P-349; copies of NAVFAC P-349 may be obtained through proper channels from the Naval Supply Depot, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

TRAINING FILMS

Training films available to naval personnel are a valuable source of supplementary information on many technical subjects. Films on various subjects that may be of interest are listed in the United States Navy Film Catalog, NAVAIR 10-1-777, published in July 1971. Use supplement dated January 1973. Copies may be ordered in accordance with the Navy Stock List of Forms and Publications, NAVSUP 2002. Supplements to the Film Catalog are distributed to catalog holders.

When selecting a film, note its date of issue listed in the film catalog. As you know, procedures sometimes change rapidly. Thus, some films become obsolete rapidly. If a film is obsolete only in part, it may sometimes be shown effectively if before or during its showing you carefully point out to trainees the procedures that have changed. For this reason, if you are showing a film to train other personnel, take a look at it in advance if possible, so that you may spot material that may have become obsolete and verify current procedures by looking them up in the appropriate sources before the formal showing.

CHAPTER 2

SUPERVISION

As a CM1 or CMC, you will be given more responsibilities based on your newly acquired knowledge. Your ability to properly instruct your subordinates in the technical aspects of their various duties and your effectiveness as a manager of people will be the true test of your worth as a supervisor. Each activity or duty station will present new challenges in effectively carrying out your job. The purpose of this chapter is to present some of the factors to consider in carrying out your new supervisory responsibilities.

The type of activity to which you are assigned will determine just how you carry out your supervisory responsibilities. But, applying effective techniques of supervision, maintaining discipline, achieving teamwork within your group, knowing how to get along with your men and superiors—these and other basic qualities of a supervisor will help you make a successful career in the Navy no matter what the activity to which you may be assigned.

THE SUPERVISORY POSITION

To most of us, it is a wonderful feeling to realize that we have generated sufficient influence in the eyes of our superiors and have been promoted to a supervisory position.

Supervision involves working with people, and a major responsibility of a supervisor is production. A good supervisor knows how to get a job done by getting the most out of his men. As a word of caution, however, the drive for production must not be overshadowed by consideration for the human element. People are not machines, and the supervisor who treats them as such will find that no amount of pressure will permanently increase the production rate. While a good supervisor wants to achieve a high level of production, he also wants his men to produce willingly and to show an interest in their work. If you have had only a small amount of supervisory experience, you are no doubt aware of the fact that the job of a supervisor is not as easy as it might sometimes appear. The following discussion will give you an idea of some of the major factors involving the supervisory position.

COMMON MISTAKES

In learning any job, learning what NOT to do is often as important as learning what to do. The following are some common mistakes which new supervisors tend to make, and which a new supervisor should avoid.

Your first days as a new supervisor are mighty important. Your men will be watching you to see how you react to this new responsibility. Your superiors will be observing you, too. This is the period to avoid some of the common mistakes made by supervisors.

"New broom" tactics are out! It is not unusual to see an inexperienced supervisor go into his new job with the idea that "things are going to be different around here." He wants to make a big showing, or he lets it be known that he didn't like the way the last supervisor operated. He has forgotten a very potent psychological factor called "resistance to change." People fear and resent change. It is far better to let your men know that nothing will be changed for the time being; and, after you get your feet on the ground, to gradually make the necessary changes.

Don't make promises in order to gain your men's friendship and support. Even a hinted or implied promise can sometimes be dynamite.

Avoid dictatorial practices; they are fiercely resented. An overshowing of authority during your first days on the job will be particularly noticed.

Playing favorites, being partial to former friends, ignoring the more timid of your men, and assigning the best jobs to a chosen few will rapidly break down the morale of your shop or crew.

Careless remarks, which would go unnoticed if they came from one of the crew, take on new significance when they come from a supervisor. You must carefully weigh your remarks when members of your shop or crew are listening.

Failure to delegate work and fearing to trust subordinates are common failings of a new supervisor, and the result is that soon he becomes so stacked up with work that he bottlenecks the whole unit.

When you make a promise to have a vehicle ready to go at a certain time and you are unable to keep that promise, accept the blame yourself. There may be a good reason for your inability to keep your promise or the fault may lie with one of your subordinates, but the important thing is that you accept the responsibility and do not pass the buck. Passing the buck when something goes wrong is a sure way to lose the respect of your men. And above all, don't lose your temper in front of your men. A man must be master of himself before he can control others.

THE FINE LINE

A supervisor must draw a fine line in his relationships between himself and his men. Do not assume a false dignity; but at the same time, the old "buddy-buddy" relationships that you used to enjoy are no longer appropriate. Drawing this fine line is one of the most difficult parts of the job of a new supervisor, but it must be drawn. It is understood that the first class who is the shop supervisor or crew leader has the more difficult job in drawing this fine line, especially when on battalion duty. He wears the same uniform, and in many cases eats and sleeps with his subordinates. He also attends the same clubs, but he must ensure that his subordinates understand that his general conversation in the relaxed atmosphere of the club and his comments on the job carry different weights and have different values. This does not mean that the supervisor has free rein to act 180° opposite of the way he acts in the shop, but it does allow him some relaxation. To accomplish this task and maintain balance, ask your men for advice and help rather than give the impression that you know it all. Let the men know that you have confidence in them; maintain a friendly but conservative attitude; treat the men alike; be consistent; and set a good example yourself.

SUPERVISORY DUTIES AND RESPONSIBILITIES

A specific list of duties and responsibilities can be made concerning only a specific position; however, here are some typical duties and responsibilities:

1. Getting the right man on the job at the right time.
2. Using and placing materials economically.
3. Preventing accidents and controlling hazards.
4. Keeping morale high.
5. Maintaining quality and quantity of work.
6. Keeping records and reports.
7. Maintaining discipline.
8. Planning and scheduling work.
9. Training your men.
10. Procuring the tools and equipment to do the work.
11. Inspecting, caring for, and preserving of tools and equipment.
12. Giving orders and directions.
13. Maintaining liaison with other units.
14. Checking and inspecting jobs and men.
15. Promoting teamwork.
16. Maintaining good housekeeping on the job.
17. Keeping operations running smoothly and efficiently.

By analyzing the typical duties and responsibilities listed above, we find that the following major areas are common to all supervisory positions:

1. Production.
2. Safety, health, and physical welfare of the men.
3. Development of cooperation.
4. Development of morale.
5. Training and development of subordinates.
6. Records and reports.
7. Balanced supervision.

ADMINISTRATIVE DUTIES

As you advance in rating, you can expect your job to require an increased amount of paperwork. If you have to spend a great deal of time doing paperwork, you may want to assign an assistant to handle part of it; however, you will

be responsible for seeing that the work is done right. Keeping all your records and reports up to date will enable you to keep a close check on each job, each crewmember and each piece of equipment under your supervision. Records and reports provide a means of checking the accomplished job progress as against the planned job progress. They also serve to summarize the experience gained on the present project, and become highly valuable aids in the planning and scheduling of future projects.

Your activity will have standard forms and blanks for keeping some of the required records and for making certain supply transactions; for example, job orders, work requests, and requisitions. In addition to these standard forms, various forms used for records and reports often are designed locally, and such forms may differ from one activity to another. At most activities you may find it advantageous to maintain logs, notebooks, charts, and so on, of your own design to meet your own specific needs. Some of the common types of records and reports that you may have to design as a supervisor are discussed below.

A WORK PROGRESS LOG is a record of all current and completed work accomplished by your shop and by each man assigned to the shop. You may design your own work progress log or it may be supplied by your activity; in any event, it should contain at least the following information for each job:

1. Shop repair order (SRO) number.
2. Date that the shop repair order was recieved.
3. Name of the unit requesting the job.
4. Brief description of the job.
5. Names of the men assigned to work on the job.
6. Number of man-hours required to complete job.

A JOB ORDER PROGRESS RECORD SHEET is a sheet for recording the status of all work currently being performed in the shop. At some activities a progress record sheet is made up at the close of each working day and submitted to the company office; a similar type of record sheet may be designed and submitted to show progress achieved on projects in the field. On the job order progress record sheet, all uncompleted job orders are listed by numbers; a brief description of each job should also be given, together with the date the job order was received. A chart should be provided to indicate the percentage of work completed on each job.

A MATERIAL EXPENDED RECORD is a very useful record for keeping track of the status of materials. (However, it might be noted that a record of this kind is utterly worthless unless it is faithfully maintained.) This record can best be kept in a notebook, with a separate section of the notebook being used for each type of material your shop uses. The information on a material expended record should include the date the material is received, the amount of material received, the date material is expended, the amount of material expended, the job order on which the material is used, and the balance of the material remaining on hand.

It is advisable that you, as a shop supervisor, also keep an EQUIPMENT LOG to list all portable tools for which you are responsible and to show where these tools are located—in the shop, storeroom, toolroom, or assigned to an individual. An up-to-date equipment log with adequate tool descriptions—make, model, and serial number—will help you at inventory time.

COMCBPAC/COMCBLANT has general forms that will serve in most situations; however, when you are assigned to CONUS/overseas shore duty and public works billets you may have to design and submit a DAILY MAN-HOUR REPORT. This report must include the work performed by the reporting unit and, when applicable, work performed by civilian labor, including indigenous, and military personnel of other activities. In making the daily man-hour report, you should also include labor expenditures.

These enable the Operations Office to determine labor expended on project work, to determine the effectiveness of labor performed by administrative and support personnel, and to develop better labor usage standards.

As stated previously, each activity is likely to design its own forms for recording and reporting various work situations; but regardless of which form you use, fill it out properly and submit it when due.

TRAINING AND DEVELOPMENT OF SUBORDINATES

Each battalion's training program is formulated to provide personnel with the skills needed to accomplish the battalion's current and mobilization missions. The program is developed in

accordance with the pattern, priorities, and tempo established by the commanding officer. It covers many phases from orientation courses to special technical courses. The success of a battalion training program depends upon such factors as operational commitments, policies, and directives from higher authorities; experience and previous training of the personnel; and training facilities available. Although much of the construction training will be provided by Class A, B, and C Schools, as well as special SEABEE training courses, additional skill and experience must be acquired in the battalion.

TRAINING ORGANIZATION

Navy regulations state that the executive officer will supervise and coordinate the work, exercises, training and education of personnel of the command. (See figure 2-1). The executive officer will supervise the training of battalion officers, coordinate the planning and execution of the training program and, when necessary, act to correct deficiencies in the program. He does this in his capacity as chief staff officer (CSO). His principal assistant is the plans and training officer (S-2).

Company commanders are directly responsible for the training of their company personnel and for the fulfillment of training goals established by the commanding officer. The company commanders will help formulate training programs; supervise training of subordinate officers; and direct technical military and general training of their companies. The battalion service department heads are responsible for the individual training of personnel in the departments. They conduct training for advancement and administer the OPNAV-sponsored general training. Platoon leaders observe closely the training progress of the men in their platoons. They directly supervise on-the-job construction and military training. All petty officers assume the responsibility for training their men and must be able to conduct effective training courses utilizing lectures, discussions, project work, and so on.

The plans and training officer is generally assisted by a permanently assigned staff of three or four petty officers and by additional personnel on a part-time basis as necessitated by the

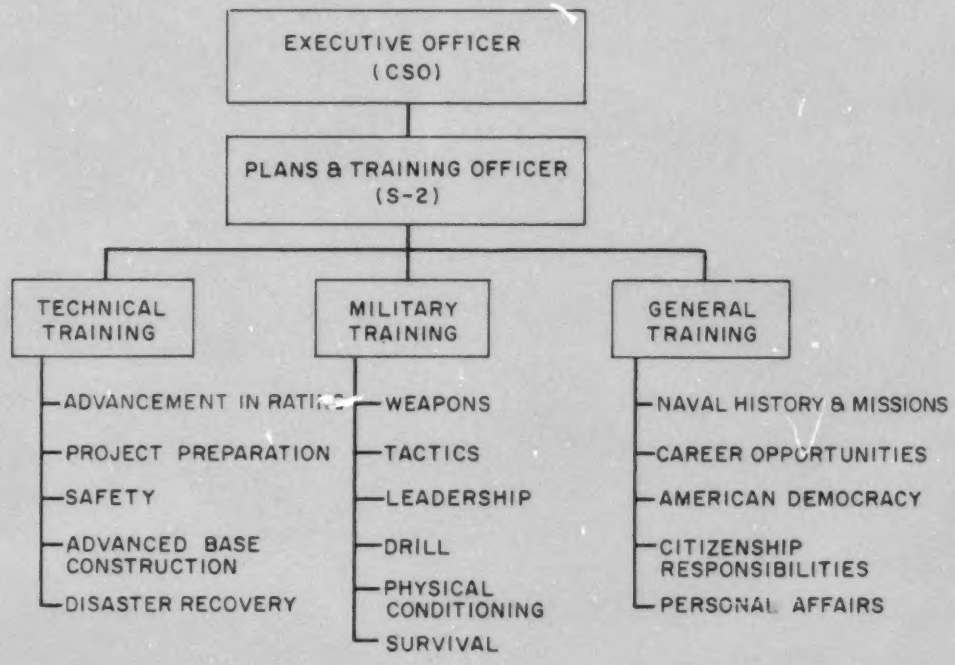

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Figure 2-1.—Battalion training organization chart.

battalion's formal training workload. This group is generally headed by a chief petty officer, and its members often function as training instructors. Although responsible for the entire battalion training program, this group is primarily concerned with the formulation and administration of the formal military training program and that part of the technical training program which includes advanced base construction and disaster recovery. The other aspects of the technical training and general training programs are formulated and administered within each company, but should correspond to the general guidelines established by the plans and training officer.

In the Amphibious Construction Battalion (PHIBCB), the training officer may serve as assistant to the operations officer. He arranges and schedules all formal training of officers and enlisted men, performing essentially the same duties as the plans and training officer of the Naval Mobile Construction Battalion (NMCB). However, the training program planned by the training officer of an PHIBCB is tailored to meet the specialized mission of the PHIBCB. It provides the knowledge that operational teams and crews apply in carrying out all phases of their primary missions. Included are seamanship, the installation and operation of causeway piers, and fuel systems and beach salvage techniques.

In general, training for both the MNCB and the PHIBCB should be closely integrated and coordinated with daily operations of the battalion. The adopted training plan and organization must not interfere with essential construction functions. Nevertheless, the construction schedule should be flexible so training opportunities that will expedite the construction schedule are not neglected. Furthermore, every opportunity should be taken to derive training benefits from routine operations.

TRAINING NEEDS

Training for advancement is a continuous concern of all personnel within a battalion, whether at the company or platoon level.

In homeport, training programs become the primary mission. The NMCB is expected to spend about 75 percent of the available man-days in formalized technical, military, and general training. In addition, the planning and estimating group may be considered to be involved with on-the-job training. Shortly before an NMCB returns to homeport, it sends an advance party to the homeport regiment to prepare the training schedule for the battalion's homeport stay. Although this advance party performs other than training functions necessary for the battalion's arrival, it prepares for instructors, sets up material support, and obtains quotas for schools. All personnel are trained in the areas of technical, military, and general topics. However, the program may be tailored to meet the specialized mission of the battalion's next deployment. If one of the projects scheduled is to be construction of an airstrip, there will undoubtedly be a great deal of site preparation going on. You will need to see how many qualified Construction Mechanics are available; you might need to train more men to maintain and repair equipment. Whenever an uncommon work item of sufficient magnitude is encountered during a forthcoming deployment, it should be accomplished in a manner which will allow the majority of your personnel to gain experience and training in the operation.

Take inventory of the skills the men in your crew possess, whether it is through actual job experience or through some type of training program. After you have made this study, you can easily see whether the required skills for a particular job match the available skills. When they do not match, you have a good indication that training is needed to bring the men up to the desired level of proficiency. In some cases, you will need to conduct refresher training; in other cases, you will have to give instructions on new techniques.

As a supervisor, you may also check your men's service records, conduct a PRCP interview with each man, (more on this later), and select those best suited for training given at a Class A, B, or C School.

ON-THE-JOB TRAINING

A good supervisor is invariably a good teacher. Your success as a supervisor depends largely upon your ability to accomplish tasks through the efforts of your men. In order to do this, you will probably have to devote a large part of your time to the training and development of your subordinates. Some supervisors estimate that from 50 to 80 percent of their time is spent in instructing.

A reputation for the development of subordinates is well worth attaining. Some supervisors can develop outstanding organizations even from

personnel who may not appear promising. Men are proud to work under such a supervisor, and they may brag for years that they once worked for chief so-and-so or so-and-so CM1. These men are often in special demand. The supervisor who acquires a reputation for developing outstanding men is top executive material; he is following the Navy principle that "the greatest contribution the supervisor can make is the development of the men under him." In every case, such a supervisor possesses the desire and ability to teach.

Your ability to teach can multiply your effectiveness. If you have a skill, knowledge, or attitude of value to the Navy and can impart that skill, knowledge, or attitude to ten others—you have multiplied your effectiveness ten times!

Good teaching is an art. The art of instruction requires careful study. Most untrained supervisors think they know how to instruct, but the results do not bear out their belief.

The first problem in teaching is to decide what you are going to teach and how much to teach at one time. Most new instructors try to teach too much at a time. They expect the trainee to know almost as much as they do. They forget that what seems simple to them may be very difficult for an inexperienced trainee. On your job, you have been interested in increasing your own efficiency as a skilled worker. Now, you must look at that job from a beginner's point of view. You will need to break down your job into small parts and teach these small parts one at a time. This process is called the "job breakdown."

Next, it is important to arrange the simple teaching units thus obtained in a logical sequence, so that the trainee may be taught each unit in the most logical and effective order. When you are dealing with several trainees at one time, it is particularly valuable to keep a record of each trainee's progress through each of the units, so that you may be sure that no trainee has missed any of the units.

Most important of all, you must go through each lesson in advance, putting yourself in the learner's place and asking yourself, "Exactly what steps do I go through to do this job? What happens at each step? What do I have to know about each step?" By carefully recording the process on paper—showing the important steps in order and what the learner needs to know about each step—you create a simple form of "lesson plan."

In actual practice, most supervisors probably do these things mentally whenever they undertake to explain a job to a new man. However, putting the lesson plan down on paper serves three important purposes: (1) it eliminates the possibility of omitting steps in the job process; (2) it makes the process clearer to the learner by giving him an outline to refer to; and (3) it becomes unnecessary for the supervisor to prepare a new lesson plan when he introduces the next new man to the job.

Finally, before you begin instruction of the men, you should have all equipment and materials ready and the work place properly arranged. There is nothing so discouraging to a new man as trying to learn a job at a desk or bench that is cluttered with papers, orders, folders, and other material. Have at the work place only what is needed for the immediate job. Give the man a fresh start! Neatness and orderliness on your part will encourage him to follow your example and will result in a neater, faster, and more accurate job.

In this discussion, we will not go into the details concerning the methods and techniques of instruction or the factors affecting learning. There are many good books covering these subjects, and a review of the chapter on training in Military Requirements for Petty Officer 1 & C, NAVPERS 10057-C, will be of value in your on-the-job training program. Since the biggest percentage of all Navy training is of the on-the-job type, your responsibility in this area cannot be overemphasized.

One of the key words to remember in any training situation is PREPARATION. Good preparation constitutes the major portion of the accomplishment of your lesson.

ADMINISTERING A COMPANY ACCIDENT PREVENTION PROGRAM

Each command is required to establish a safety organization to develop, organize, and direct a comprehensive accident prevention program and to provide for the promulgation and enforcement of safety precautions and safe construction techniques.

The safety program is usually under the direction of the SAFETY OFFICER (normally the Operations Officer), who is responsible for ensuring that the provisions of the Safety Manual 5100.10 and the policies directed by the Executive Officer are carried out.

In an NMCB a chief petty officer may be designated as safety chief to assist the safety officer, who usually has other collateral duties.

The safety officer lays out the safety program, after conducting job analyses and consulting construction supervisors. He maintains an adequate safety library, provides and equips safety bulletin boards, and obtains and distributes safety educational materials, such as posters, pamphlets, films, books, and visual aids. He initiates and encourages activities designed to stimulate and maintain interest in safety. He cooperates with construction supervisors in the selection and placement of warning signs. He investigates and reports all accidents; in doing so he recommends ways of preventing their recurrence.

SAFEGUARDS AND SAFETY EDUCATION

Many supervisors feel that it is only necessary to provide safeguards, after which safety will take care of itself. Provision of safeguards is a move in the right direction, but it alone will not get good results. To maintain a good safety record, you, as the supervisor, need to employ a combination of safety devices and safety training. If each man has had sound safety training, he will be able to guard against hazards for which safety devices are impracticable. You must, however, train every man in the use of safeguards, explaining why, as well as how, they should be used. How many times have you seen a man shut off the power to a motor-driven machine and then walk away from it before it has stopped turning? This man knew how, but not why. By providing the necessary training, the alert supervisor makes sure his men are not careless with safeguards.

Standup safety meetings should be held in the shop once every week. The meetings should be held at or near the work area. Instead of a routine safety lecture, it is better to hold a group discussion on specific accidents that are to be guarded against or that have happened in the unit. The men should be encouraged to express their ideas. Your group should reach a conclusion as to how specific accidents can be prevented.

Another type of safety meeting is one in which the supervisor presents a safety problem that has developed because of new work or new equipment. Again, the men should be invited to express their ideas.

In a third type of safety meeting, actual demonstrations and practice by the group are carried out. You demonstrate how to lift, for example, and then have the men practice lifting.

Or say your subject is safe use of a portable grinder. Bring a portable grinder to the meeting and <u>show</u> how to use it—do not just <u>talk</u> about how to use it. Again, let the men practice after they have been shown how.

Make these meetings interesting; it takes a lot of ingenuity to keep them from becoming dull. Consider having the men themselves rotate as leaders of the safety meetings—an excellent device to maintain interest. Hundreds of good motion pictures and other visual aids are available on safety subjects. Use them! But select subject matter that is timely and fitting. Never complain or scold at these meetings. Also, make sure to set a time limit for each meeting, and avoid exceeding it.

SAFETY INSPECTIONS

Safety inspections are a never-ending responsibility of the supervisor. The supervisor does not follow a strict schedule of safety inspections; instead he maintains a continual alertness for all potential safety hazards around him. He ensures that all safeguards in the work areas are being adhered to and that all protective equipment is being used when required. For example, you will be required to hold safety inspections of both the shops and the equipment used by all of the men under your supervision. The shop areas consist of the heavy construction shop, the automotive shop, the tire shop, and the battery shop. The equipment includes shop tools, power tools, jacks, hoists, electrical equipment, and firefighting equipment.

During inspection of the work areas you should ensure that: (1) there is proper ventilation and lighting, (2) goggles, rubber gloves, aprons, safety shoes, shields, and special gloves are provided where required, (3) accumulation of waste, rags, or trash is not allowed, (4) proper fire fighting equipment is available and in the proper location, and (5) welding equipment is separated from the rest of the shop area and screens are provided to protect the eyes of others in the immediate area.

When inspecting equipment ensure that (1) all tools are in good repair, free of damage, clean, and properly grounded if electrical, (2) all jacks and hoists are free of damage and

operating properly, (3) all firefighting equipment is charged, and of the correct type, amount, and in correct location, and (4) all electrical cords are in good repair.

Make sure all discrepancies found during the inspection are corrected immediately.

ACCIDENT REPORTING

When an accident occurs in your shop, office, or within your crew, you must fill out an OPNAV Form 5100/1 Accidental Injury/Death Report (figures 2-2 through 2-5). This form provides a method of recording the essential facts concerning an accident, from which data for use in accident prevention can be compiled. Item 27—"Corrective action taken/recommended"—is the most important part of this report. Your response to this item provides a clue to your attitude toward safety. Too many supervisors respond with, "The man was warned to be more careful." Such a response is useless since it does not tie in with the rest of the report. If an unsafe working condition is the cause of the accident, you cannot correct it by warning the man to be more careful. Study the report; analyze it; then take corrective action. When properly used, this report is one of your best accident prevention tools. In many cases, the difference between a minor accident and a major one is a matter of luck. Do not ignore accidents that result in small cuts and bruises; investigate the reasons for them and correct the causes. If you do this, you will have a safe and efficient shop or office.

ACCIDENT INVESTIGATION

To fill out OPNAV Form 5100/1 properly, as shown in figures 2-2 and 2-3, you must conduct an accident investigation to get answers to questions such as those in the six categories below.

1. Unsafe conditions. Was the equipment improperly guarded, unguarded, or inadequately guarded? Was the equipment or material rough, slippery, sharp-edged, decayed, worn, or cracked? Was there a hazardous arrangement, such as congested work space, lack of proper lifting equipment, or unsafe planning? Was there proper illumination or ventilation? Was the man dressed properly for the job? Was the man provided with proper respirator, goggles, gloves, etc?

2. Type of Accident. Was the man struck by an object? Did the man fall at the same level or to a different level? Was he caught in or between objects? Did he slip (not fall) or overexert himself?

3. Unsafe Act. Was the man operating a machine without proper authorization? Was he working at an unsafe speed, that is too fast or too slow? Was a safety device made inoperative, that is blocked out or removed? Was a load made unsafe or were tools or equipment put in an unsafe place where they would fall? Did someone fail to wipe oil, water, grease, paint, etc from working surfaces? Did the injured man take an unsafe position of posture? Did he lift with a bent back or while in an awkward position? Did he lift jerkily? Was he riding in an unsafe position on a vehicle? Was he using improper means of ascending or descending? Was the injury caused by failure to wear the provided safe attire or personal protective devices, such as goggles, gloves, masks, aprons, or safety shoes?

4. Unsafe Personal Factor. Was the man absentminded or inattentive? Did he fail to understand instructions, regulations, or safety rules? Did he willfully disregard instructions or safety rules? Was he unaware of safe practices, unpracticed, or unskilled? Was he unable to recognize or appreciate the hazards? Did he have a bodily defect, such as poor eyesight, defective hearing, or hernia?

5. Type of Injury. Did he sustain a cut, bruise, sprain, strain, hernia, or fracture?

6. Part of Body Afftected. Did the injury involve an arm, leg, ribs, feet, fingers, head etc?

These categories suggest some of the things (not all) a supervisor must investigate and report when accidents occur. Remember there are some questions in these categories that request medical information which can only be obtained from a doctor. Each accident is different, and each should be investigated and judged on its own merits. Do not jump to conclusions. Start each investigation with an open mind. The most important reason for any accident investigation is prevention of a similar accident.

THE PERSONNEL READINESS CAPABILITY PROGRAM

The Personnel Readiness Capability Program (PRCP) is a management tool which was developed in the mid-1960's by the staff of the

ACCIDENTAL INJURY/DEATH REPORT
OPNAV FORM 5100/1 (5-88) S/N-0107-778-0010

FOR OFFICIAL USE ONLY

SPECIAL HANDLING REQUIRED IN ACCORDANCE WITH OPNAVINST 5100.11

REPORT SYMBOL OPNAV 5100-3

TO: COMMANDER, NAVAL SAFETY CENTER, NAVAL AIR STATION, NORFOLK, VA. 23511

1. REPORTING COMMAND: NAVAL CONSTRUCTION BATTALION CENTER PORT HUENEME, CALIFORNIA 93041

2A. COMMAND AUTHORITY EXERCISED BY: CONSTRUCTION CENTER

2B. GCM AUTHORITY EXERCISED BY:

3. REPORT NUMBER: 5

4. NAME OF PERSON INJURED/KILLED (FIRST, MIDDLE, LAST): ANDERSON, John P.

5A. SERVICE/BADGE NO.: B4823456

5B. SOCIAL SECURITY NO.: 247-83-2248

6. RANK & DESIGNATOR/RATE AND MEC/CIVILIAN OCCUPATION: CM2, USN

7. SEX: M

8. AGE: 24

9A. TIME IN SERVICE (MIL ONLY): 6 Years

9B. YEARS EXPERIENCE (CIV ONLY):

10A. MIL: [X] USN [ ] USMC [ ] OTHER

10B. CIV: [ ] EMPLOYEE [ ] DEPENDENT [ ] OTHER

11A. DUTY STATUS (MIL): [ ] EXT ACT DU [X] ACDUTRA [ ] DRILL [ ] TRAVEL [ ] F/T IB [ ] UA [ ] OTHER

11B. DUTY STATUS (CIV): [ ] PER. [ ] TEMP. [ ] TRAVEL [ ] UNAUTH WORK [ ] OTHER

12. DATE AND TIME OF INJURY

HOUR	DATE	MONTH	YEAR	DAY OF WEEK
0950	19	Apr.	19-	Thursday

13. PLACE OF OCCURRENCE: [ ] ABOARD SHIP [X] ASHORE
DESCRIBE LOCATION: Automotive Shop

14. DAYS LOST/CHARGED: (0)

15. WEATHER/NATURAL DISASTER: NA

16. LIGHT CONDITIONS AT SITE: Good

17. DESCRIPTION OF EVENTS: (DESCRIBE THE CONTRIBUTING EVENTS LEADING UP TO THE INJURY/DEATH SO THAT THE REVIEWING OFFICIAL WILL HAVE A CLEAR PICTURE OF WHAT CAUSED THE INJURY/DEATH. SELECT THE APPROPRIATE ENTRY FROM EACH MAJOR FACTOR CATEGORY LISTED ON BACK OF INSTRUCTION SHEET AND ENTER IT WITH AMPLIFYING DETAIL IN BOXES 19 THROUGH 25 BELOW.)

Petty Officer ANDERSON was standing on the front bumper of a 5-ton truck leaning over the radiator grill to inspect the radiator hoses and fan belts when his feet slipped off the wet bumper, causing him to fall on the upper section of the radiator grill.

WITNESSES: NAME, RANK/RATE, ADDRESS: None

18. KIND OF INJURY: Abrasion

19. BODY PART INJURED: Chest

20. SOURCE OF INJURY (OBJECT, SUBSTANCE, ETC. WHICH CONFINED THE BODY AND/OR CAUSED PERSONAL INJURY): Vehicle--Radiator Grill

21. KIND OF ACCIDENT (FALL, COLLISION, STRUCK BY, ETC.): Striking Against

22. HAZARDOUS CONDITION (WHAT CONDITION CAUSED, PERMITTED, CONTRIBUTED TO ACCIDENT WHICH RESULTED IN INJURY): Wet Bumper [ ] NOT APPLICABLE

23. AGENCY (AND AGENCY PART) OF ACCIDENT (OBJECT, SUBSTANCE, ETC. TO WHICH THE HAZARDOUS CONDITION APPLIES): U.S. Navy [ ] NOT APPLICABLE

24. UNSAFE ACT (WHAT PERSONAL ACTION CAUSED OR ALLOWED ACCIDENT TO OCCUR): [X] BY INJURED [ ] BY ANOTHER [ ] NOT APPLICABLE

25. UNSAFE PERSONAL FACTOR (MENTAL OR PHYSICAL CONDITION WHICH RESULTED IN OR CONTRIBUTED TO THE UNSAFE ACT): Failure to use step stands

26. REASON FOR BEING ON GOVERNMENT PROPERTY (REGULAR DUTY ASSIGNMENT, CIV EMP, PATIENT, VISITOR, BUSINESS, ETC.): Regular duty assignment

2,462

Figure 2-2. — Accidental Injury/Death Report, OPNAV Form 5100/1 (Front).

OPNAV FORM 5100/1 (3-69) (BACK)

27. CORRECTIVE ACTION TAKEN/RECOMMENDED (WHAT ACTION WILL HELP PREVENT SIMILAR ACCIDENT OF THIS TYPE?):

Instructed Petty Officer ANDERSON in the use of the step stands with non-skid treads which are provided by the shop for this type work.

28. SIGNATURE OF PERSON PREPARING REPORT	29. TITLE AND GRADE	30. DATE
Jim Nelson Jim Nelson	CMCS, USN	19 Apr. 19-

31. REVIEW AND COMMENTS OF SAFETY OFFICER OR COMMANDING OFFICER

32. SIGNATURE	33. TITLE AND GRADE	34. DATE

ADDITIONAL INFORMATION WHEN REQUIRED BY JAG

35. CONDITION OF INDIVIDUAL AT TIME OF THIS OCCURRENCE:
UNDER THE INFLUENCE OF: ☐ ALCOHOL ☐ NARCOTICS ☐ BARBITURATES ☐ OTHER (SPECIFY) _____ ☐ NOT APPLICABLE
☐ UNABLE TO DETERMINE DUE TO PHYSICAL CONDITION EXAMINER _____

36. BASIS FOR ABOVE OPINION:
A. CLINICAL FINDINGS: _____
B. BIOLOGICAL SPECIMEN TAKEN: ☐ NO ☐ YES TIME _____ LABORATORY TO WHICH SPECIMEN SENT _____
TYPE OF TEST RESULT OTHER TESTS/RESULTS

37. MEDICAL OFFICER'S FINDINGS RELATIVE TO NATURE AND EXTENT OF INJURY:

38. WAS SUBJECT HOSPITALIZED AS A RESULT OF THIS OCCURRENCE? ☐ YES ☐ NO	39. IF THE SUBJECT WERE ALREADY ON THE SICK LIST FOR OTHER REASONS AT TIME OF INJURY WOULD THIS INJURY IN ITSELF HAVE REQUIRED HOSPITALIZATION? ☐ YES ☐ NO ☐ NOT APPLICABLE
40. IT IS POSSIBLE THAT THE FOLLOWING DISABILITY MAY RESULT: ☐ PERMANENT PARTIAL ☐ PERMANENT TOTAL	41. DATE OF EXPIRATION OF ENLISTMENT/TERM OF OBLIGATED SERVICE:
42. IF DECEASED, WAS AUTOPSY CONDUCTED? ☐ YES ☐ NO	IF YES, ATTACH COPY OF AUTOPSY PROTOCOL

43. ADDITIONAL INFORMATION FOR RESERVISTS: IF RESERVIST WAS ORDERED TO ACTIVE DUTY TRAINING OR INACTIVE DUTY TRAINING, GIVE THE FOLLOWING INFORMATION:

MEMBER REPORTED FOR DUTY OR DRILL		DISMISSED FROM DUTY OR DRILL		INJURY	
DATE	TIME	DATE	TIME	DATE	TIME

44. MEDICAL OFFICER'S SIGNATURE	45. GRADE	46. DATE

47. IT IS THE OPINION OF THE UNDERSIGNED THAT THE INJURY/DEATH IN QUESTION WAS INCURRED IN THE LINE OF DUTY AND NOT AS THE RESULT OF THE SUBJECT MAN'S OWN MISCONDUCT. ☐ YES ☐ NO

COMMANDING OFFICER (OR ONE AUTHORIZED TO SIGN BY HIS DIRECTION - IF LATTER SO INDICATE)

48. SIGNATURE	49. TYPED NAME AND GRADE	50. DATE

51. ACTION OF OFFICER EXERCISING GENERAL COURT-MARTIAL JURISDICTION:
DATE: _____
FROM:
TO: JUDGE ADVOCATE GENERAL OF THE NAVY

SIGNATURE AND TYPED NAME OF OFFICER EXERCISING GCM AUTHORITY (OR ONE AUTHORIZED TO SIGN BY DIRECTION)

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Figure 2-3.—Accidental Injury/Death Report, OPNAV Form 5100/1 (Back).

ACCIDENTAL INJURY/DEATH REPORT
OPNAV FORM 5100/1 (5-69)

INSTRUCTIONS FOR ACCIDENTAL INJURY/DEATH REPORT

Print with pen or type; items not applicable or contributory to the injury/death will be marked N.A.

Block 1. Reporting Command - Self-explanatory.

Block 2A. Command Authority Exercised By. In the case of ships and air units this is the Type Commander. For shore activities this is the command that provides command and support (ie COMSERVLANT in the case of NAVSTA NORVA, COMNAVSHIPSYSCOM in the case of a ship yard, etc.)

Block 2B. CCM Authority Exercised By. Self-explanatory. Use only when report is required by JAG.

Block 3. Report Number. Reports will be serialized consecutively by each reporting command/activity during the fiscal year. (i.e. 2-69 is the second report of fiscal year 1969)

Block 4. Name of Person Injured/Killed. Self-explanatory.

Block 5A. Service/Badge Number. Self-explanatory.

Block 5B. Social Security Number. Self-explanatory.

Block 6. Rank & Designator/Rate & SEC/Civilian Occupation. Self-explanatory.

Block 7. Sex. Self-explanatory.

Block 8. Age. Self-explanatory.

Block 9A. Time in Service (Mil Only). Indicate in years only.

Block 9B. Years Experience (Civ. Only). Indicate number of years experience in present occupation, including years of experience gained in that occupation in other government or private industry employment. In cases of injury or death to civilians other than employees of the Department of the Navy, mark "N.A."

Block 10. Employment Status. In the event the line "Other" is selected for either military or civilian, specify as contract employee, visitor, Army, Air Force, etc.

Block 11. Duty Status. For either military or civilian check all applicable boxes.

Block 12. Date and Time of Injury. Give the hour on the basis of the 24 hour clock using four digits. Use two digits each for the date, month and year.

Block 13. Place of Occurrence. In describing the location enter point locator, weather deck, flight deck, machine shop, galley, etc. as appropriate.

Block 14. Days Lost Charged. For fatal injury or missing persons, enter 6000 days. For all other injuries enter the number of calendar days of disability, or time charges using the schedule of charges, Table 1, Appendix I. Whenever the schedule of charges is used the actual number of calendar days of disability is not entered.

Block 15. Weather/Natural Disaster. If a factor, describe weather conditions or natural disaster which contributed to the injury.

Block 16. Light Conditions at Site. Describe outside or internal lighting conditions, as applicable, existing at the immediate site and time of accident.

Block 17. Description of Events. Enter narrative description of circumstances and events which directly or indirectly led to the injury, physical impairment or death. Include sufficient information to clarify or expand upon the character and scope of data to be entered in blocks 18 through 25 of the report. Accidental injury/death reports in all cases resulting from a ship accident will reference the applicable ship accident report serial in this block. Include in this block, as appropriate, comments on the following:

a. Time injured person first seen by medical officer/representative.
b. Disposition of injured person; i.e. treated and retained aboard or transferred to another ship (military personnel) or transferred to a hospital for treatment (military and civilian personnel).
c. In cases of exposure to toxic fumes/chemical poisons, describe type of substance, concentration and type of exposure.
d. Describe additional causative/contributing factors not described in blocks 20 through 25 and indicate (D) for a definite cause, (S) for a suspected cause and (F) for conditions present but not a factor. Enter name, rank/rate or grade and address of witnesses to the accident. If none, so indicate.

Block 18. Kind of Injury. Enter words from Block 18 (on reverse side of this sheet) which best describes nature of injury.

Block 19. Body Part Injured. Enter word(s) from block 19 (on reverse side of this sheet) which best describes body part affected by nature of injury.

Block 20. Source of Injury. Enter object or environment from block 20 (on reverse side of this sheet) which best describes source of injury. (NOTE: A direct logical relationship between "Source of Injury" and "Kind of Injury" must be established).

Block 21. Kind of Accident. Enter action, motion or type of contact from block 21 (on reverse side of this sheet) which best describes means by which injured person came in contact with previously selected "Source of Injury". (NOTE: A direct logical relationship between the "Source of Injury" and "Kind of Accident" must be established.)

Block 22. Hazardous Condition. Enter the condition from Block 22 (on reverse side of this sheet) which best describes the hazardous conditions which permitted or occasioned occurrence of previously selected "Kind of Accident". (NOTE: A direct logical relationship between "Kind of Accident", "Hazardous Condition" and "Agency of Accident", which is to follow, must be established).

Block 23. Agency (and Agency Part) of Accident. Enter the object or environment from Block 20 (on reverse side of this sheet) which best describes the agency to which the hazardous condition applies. In addition, describe the part of the agency which is unsafe. For instance, if the agency is a table saw from which the blade guard has been removed, enter the words "circular saw - blade." In some agencies such as a length of pipe, rope, lumber, etc., no agency part is required to be named. The rule for agency part is - if corrective or preventive action for the part involved is different from the action on any other part of the agency, name the agency part involved. (NOTE: A direct logical relationship between "Hazardous Condition" and "Agency of Accident" must be established). If there is no hazardous condition there can be no agency or agency part of accident, and all three items shall be described as "Not Applicable".

Block 24. Unsafe Act. Enter the act or omission from Block 24 (on reverse side of this sheet) which best describes unsafe act which permitted or caused occurrence of previously named kind of accident. (NOTE: A direct logical relationship between "Unsafe Act" and "Kind of Accident" must be established).

Block 25. Unsafe Personal Factor. Enter the reason from Block 25 (on reverse side of this sheet) which best describes the unsafe personal factor which led to the "Unsafe Act" or contributed to the injury. (NOTE: If there was an unsafe act committed, an unsafe personal factor should always be selected. If no unsafe act was committed there may still, however, be an unsafe personal factor which contributed to the accident).

Block 26. Reason for Being on Government Property. Self-explanatory.

Block 27. Corrective Action Taken, Recommended. List specific remedial actions which have been or should be taken to prevent recurrence of similar injury. If an entry of "unknown" or "none" seems appropriate, an explanation shall be given as to why corrective action can not be recommended. Specify whether actions have been taken or are only recommended. If the latter, what action is expected?

Blocks 28 through 30. First Signature Line. Report is to be signed and dated by the individual who prepared the report to this point.

Block 31. Review and Comments of Safety Officer or Commanding Officer. Additional recommendations may be made if appropriate.

Blocks 32 through 34. Second Signature Line. Self-explanatory.

The remainder of the report form will only be filled out in those instances where the injury/death to the military member is reportable to JAG.

a. Blocks 1-34. Prepared in accordance with above instructions.
b. Blocks 35-38. Self-explanatory.
c. Blocks 39 through 60, 62, and 64 through 66 shall be completed and signed by the medical officer on the basis of his observation or examination of the injured or deceased member and information then available to him.
d. Blocks 61, 63 and 67 through 80 shall be completed and signed by the commanding officer on the basis of his investigation (or by an officer authorized and directed by the commanding officer to investigate the incident and sign the report by direction).

29.52.3 (127E)

Figure 2-4. — Instructions for Accidental Injury/Death Report (Front)

BLOCK 18. KIND OF INJURY

AMPUTATION OR ENUCLEATION
ASPHYXIA, STRANGULATION
BURN OR SCALD (THERMAL)
BURN (CHEMICAL)
CAISSON DISEASE, BENDS
CONCUSSION, BRAIN
CONTUSION, CRUSHING, BRUISE
CUT, LACERATION, PUNCTURE, OPEN WOUND
DISLOCATION
DROWNING
ELECTRIC SHOCK, ELECTROCUTION
FOREIGN BODY LOOSE (DUST, RUST, SOOT)
FOREIGN BODY, RETAINED OR EMBEDDED
FRACTURE
FREEZING, FROSTBITE
HEARING LOSS, OR IMPAIRMENT
HEAT STROKE, SUNSTROKE, HEAT EXHAUSTION
HERNIA
*INJURIES, INTERNAL
*POISONING, SYSTEMIC
*RADIATION, IONIZING
RADIATION, NONIONIZING
RADIATION, ACTINIC
SCRATCHES, ABRASIONS
SPRAINS, STRAINS
SUBMERSION, NONFATAL
*MULTIPLE INJURIES
UNDETERMINED
*OCCUPATIONAL DISEASE, NEC
*OTHER INJURY, NEC

BLOCK 19. BODY PART INJURED

*HEAD (INCLUDING FACE)
*NECK
*UPPER EXTREMITIES
*TRUNK
*LOWER EXTREMITIES
*MULTIPLE PARTS
*BODY SYSTEM
*BODY PARTS, NEC

BLOCKS 20 & 23. SOURCE OF INJURY AND AGENCY OF ACCIDENT

*AIR PRESSURE
*ANIMALS
*BODILY MOTION
*BOILERS, PRESSURE VESSELS - PARTS
*BOXES, BARRELS, CONTAINERS, PACKAGES (EMPTY OR FULL, EXCEPT GLASS)
*BUILDINGS & STRUCTURES - PARTS
*CHEMICALS & CHEMICAL COMPOUNDS
*CLOTHING, APPAREL, SHOES
*COAL AND PETROLEUM PRODUCTS
*CONSTRUCTION MATERIALS (NOT PART OF A STRUCTURE)
*CONVEYORS, GRAVITY OR POWERED (EXCEPT PLANT & INDUSTRIAL VEHICLES)
*DRUGS AND MEDICINES
*ELECTRIC & ELECTRONIC APPARATUS, NEC
*FLAME, FIRE, SMOKE
*FOREIGN BODIES OR UNIDENTIFIED ARTICLES
*FURNITURE, FIXTURES, FURNISHINGS
*GLASS & CERAMIC ITEMS, NEC
*HAND TOOLS (NOT POWERED; WHEN IN USE, CARRIED BY A PERSON)
*HAND TOOLS (MECH. & ELEC. MOTOR POWERED; IN USE, CARRIED AND HELD BY A PERSON)
*HEATING EQUIPMENT, NEC (NOT ELEC.) WHEN IN USE (FOR ELEC. FURNACES SEE ELECTRONIC APPARATUS)
*HOISTING APPARATUS
*ELEVATORS
*HUMAN BEING
*INSTRUMENTALITIES OF WAR
*MACHINES (PORTABLE & FIXED, EXCEPT WHEELED VEHICLES)
*METAL ITEMS, NEC
*MINERAL ITEMS, NEC
*NATURAL POISONS AND TOXIC AGENTS, NEC
NOISE
*PERSONNEL SUPPORTING SURFACES (DECK, LADDER, STAGE, GROUND, PLATFORM)
*PLASTIC ITEMS, NEC
*PUMPS, ENGINES, TURBINES (NOT ELEC.)
*RADIATING SUBSTANCES AND EQUIPMENT (USE ONLY FOR RADIATION INJURIES)
*SCRAP, DEBRIS, WASTE MATERIAL, ETC., NEC (EXCEPT RADIOACTIVE)
*SHIP STRUCTURE - PARTS
*SPORTS
*TEMPERATURE (ATMOSPHERIC, ENVIRONMENTAL)
*TEXTILE ITEMS, NEC
*VEHICLES, (AIR, LAND, SEA) INCLUDING MILITARY AND INDUSTRIAL
WATER AND STEAM
*WOOD ITEMS, NEC
*MISCELLANEOUS, NEC
UNDETERMINED
*OTHER, NEC

BLOCK 21. KIND OF ACCIDENT

*STRUCK AGAINST
*STRUCK BY
*FALL OR JUMP FROM ELEVATION
*FALL OR JUMP ON SAME LEVEL
*CAUGHT IN, UNDER, OR BETWEEN
BITE OR STING, VENOMOUS AND NON-VENOMOUS
*RUBBED, ABRADED, PUNCTURED OR CUT
BODILY REACTION OR MOTION
*OVEREXERTION
*CONTACT WITH
UNDETERMINED
*OTHER, NEC

BLOCK 22. HAZARDOUS CONDITION

*DEFECT OF THE AGENCY OF ACCIDENT
*DRESS OR APPAREL HAZARD
*IMPROPER ILLUMINATION
*IMPROPER VENTILATION
*ENVIRONMENTAL HAZARD, NEC
*HAZARD OF OUTSIDE WORK ENVIRONMENT - OTHER
*INADEQUATELY GUARDED
*PLACEMENT HAZARD
*PUBLIC HAZARD
UNDETERMINED
NO HAZARDOUS CONDITION
*HAZARDOUS CONDITION, NEC

BLOCK 24. UNSAFE ACT

*WORKING ON MOVING OR DANGEROUS EQUIPMENT
*DRIVING ERRORS BY VEHICLE OPERATOR
*FAILURE TO USE PERSONAL PROTECTIVE EQUIPMENT
FAILURE TO WEAR SAFE PERSONAL ATTIRE
*FAILURE TO SECURE OR RAIN
HORSEPLAY AND DAYDREAMING
QUARRELING OR FIGHTING
*IMPROPER USE OF EQUIPMENT
*IMPROPER USE OF HANDS OR BODY PARTS
INATTENTION TO FOOTING OR SURROUNDINGS
*FAILURE TO USE SAFETY DEVICES
*OPERATING OR WORKING AT UNSAFE SPEED
*TAKING UNSAFE POSITION OR POSTURE
*UNSAFE PLACING, MIXING, COMBINING, ETC.
*USING UNSAFE EQUIPMENT
*OTHER UNSAFE ACTS, NEC
UNDETERMINED
NO UNSAFE ACT
NEC - NOT ELSEWHERE CLASSIFIED

BLOCK 25. UNSAFE PERSONAL FACTOR

UNDER INFLUENCE DRUG/ALCOHOL
FATIGUE
ILLNESS
*IMPROPER ATTITUDE
*LACK OF KNOWLEDGE OR SKILL
*BODILY DEFECTS
UNDETERMINED
NO UNSAFE PERSONAL FACTOR
*OTHER UNSAFE PERSONAL FACTOR, NEC

* SPECIFY/DETAIL

29.52.4(127E)

Figure 2-5.—Instructions for Accidental Injury/Death Report (Back).

Commander, Construction Battalions, U. S. Atlantic Fleet and subsequently implemented throughout the active and reserve Naval Construction Force (NCF). Its purpose is to provide managers at all levels of the NCF with timely personnel information which will increase their capabilities in planning, decision making, and control.

Prior to the implementation of the PRCP, personnel information was kept on an "as required" basis by various members of the unit in personal notebooks, files, and records. This information was collected as management required it to determine military and construction capabilities, training requirements, logistics support, etc. The collecting of this information was usually a time-consuming, laborious task that required a piecemeal inventory of the command's capabilities or requirements. Another way of getting this information was through the use of rough estimates. Neither way however, produced the accuracy or rapid response desired. Implementation of the PRCP helped to do so by establishing standard procedures for identifying, collecting, processing, and utilizing this information.

The Personnel Readiness Capability Program requires each participating command to gather, and continuously update, information on each member of the unit. Most of this information concerns skills acquired through actual job experience or through some type of training program. Other information such as expiration of enlistment or rotation date, is required for accurate planning. The gathering of this other information is called a SKILL INVENTORY.

SKILL INVENTORY

An accurate and current skill inventory is the backbone of the PRCP. Without it, the reliability of any planning based on information stored in the PRCP DATA BANK is questionable. Presently, all PRCP skills and other data are based on requirements established by COMCBPAC and COMCBLANT and promulgated in their joint instruction of the 1500.20 series. Additionally, these skills have been conveniently classified into five major categories:

(1) Individual General Skills. These are essentially nonmanipulative skills (knowledge) related to two or more ratings, such as construction inspection, planning and estimating, and safety inspection.

(2) Individual Rating Skills. These are primarily manipulative skills associated with one of the seven Group VIII (Construction) ratings. Some examples are: light frame construction for Builder, cable splicing for Construction Electrician, and shore based boiler operation for Utilitiesman.

(3) Individual Special Skills. These are technical skills performed by several ratings, including Non-Group VIII's. For example: forklift operation, ham radio operation, or typing.

(4) Military Skills. These are further classified into two subcategories: General Military Requirements and SEABEE Combat Readiness. Examples are disaster recovery training and mines and booby traps, respectively.

(5) Crew Experience Skills: These are gained by working with others on specific projects. Most of these projects are related to advanced-base construction, such as steel tank erection, pile driving, and SATS installion.

A skill inventory has three principle steps. First, each skill is closely defined so that each person will give it the same meaning. Second, a standard procedure for obtaining the information is developed. This procedure helps to ensure that the information, regardless of where it is collected or by whom, will meet certain standards of acceptability. The third and last step is the actual collection of the skill data and includes the procedures for submitting the data to the data bank.

Skill Definitions

A book of standard SKILL DEFINITIONS, called Book 1-PRCP Skill Definitions, contains a definition for every skill identified in the Personnel Readiness Capability Program. Each definition has been jointly approved by COMCBLANT, CONCBPAC, and CNRT (Chief of Naval Reserve Training) and is applicable to the entire Naval Construction Force.

PRCP Interviewer's Standards and Guides

The skill definitions alone do not contain sufficiently detailed information to accurately classify people, nor do they provide any classification procedures. Recognizing this, the Civil Engineer Support Office (CESO) conducted special SEABEE workshops where the PRCP Interviewer's Standards and Guides were developed under the guidance of CESO. The Guides contain

a detailed TASK ANALYSIS of each skill definition as well as standard procedures for its use. The PRCP Interviewer's Standards and Guides are the principal tools used in collecting skill data. They can be used two ways: (1) By following the interviewing procedures in each guide, a trained interviewer is able to classify people to a predetermined skill level within an acceptable degree of uniformity; and (2) by having a thorough knowledge of the tasks required of each skill, anyone so authorized can classify others to an appropriate skill level by actually observing the men perform the tasks, either in training or on the job.

Skill information obtained from interviewing or observing is submitted to the Facilities Systems Office (FACSO), Port Hueneme, California on a special form known as a TRANSCRIPT MASTER. This form, which consists of multiple sheets of carbon sensitive paper, is preprinted with every skill identified in the PRCP. Normally, it is only necessary to mark the appropriate skill levels attained, send a copy to FACSO—where the data bank is maintained—and retain a designated copy at the unit level. Complete instructions and information for using the transcript master, as well as other PRCP data processing information, can be obtained from the training officer of units participating in the program.

As an E-6 crew/squad leader, you are directly responsible for using the PRCP Interviewer's Standards and Guides to interview your men (or others) and to provide the initial information for the PRCP data bank. Subsequent UPDATING of this initial information for each man is based on either his performance on the job (which you observe) or his performance at a school. New men, however, and others returning from long periods of certain types of shore duty, may require interviewing.

PRCP INTERVIEWS

There are two types of PRCP interviews. The first and most important is the INDIVIDUAL RATING SKILL INTERVIEW. The second type is simply called OTHER INTERVIEWS. Both types require the use of the PRCP Interviewer's Standards and Guides.

Rating Skill Interviews

The individual rating skill interview must be conducted by an experienced and knowledgeable tradesman. The interviewer uses a discussion technique to classify other SEABEEs in the skill levels of the various individual rating skills. This technique requires a thorough understanding of the skills and tasks explained in the interviewing guides. Since few individuals possess the talent required to interview in all the skills of a rating, the interviewer must be mature enough to recognize his own limitations and be willing to seek assistance from others in his rating.

Other Interviews

Other interviews are used to classify people into the individual general and special skills, military skills, and crew experience. With only a few exceptions, these skills do not require an experienced interviewer; and in many cases, skill levels can be assigned to an individual on the basis of his service or training record. This should be done whenever possible to cut down on interviewing time. Then, when the man is in for interviewing, it will be just a matter of verification or of updating.

USING THE INDIVIDUAL RATING SKILL GUIDES

When assigned as an interviewer, you must obtain, read, understand, and use the PRCP Interviewer's Standards and Guides. The format of the Guides is standard. After the TITLE PAGE, you'll find the SKILL DEFINITION; then come the TASKS which are broken down into TASK ELEMENTS. See figures 2-6, 2-7, and 2-8.

Title Page

The title page serves to identify the skill and the pages which follow. For example, the sample title page in figure 2-6 identifies the Individual Construction Mechanic Skill of 332-Engine Tune-Up (Gasoline). The number 332 is a numerical code for this skill. The CONTENTS can be used to ensure that there are no missing pages. The skill definition will always be listed first. Directly under it will be .1 Skill Level 1. Under each skill level are the tasks for which you must interview each candidate to see if he is qualified to that level.

Skill Definition

Figure 2-7 illustrates an individual rating skill definition. Its significant features are: a

INTERVIEWER'S

STANDARDS AND GUIDE

for the

INDIVIDUAL CONSTRUCTION MECHANIC SKILL

of

332 - Engine Tune-up (Gasoline)

CONTENTS

		Page
332	Engine Tune-up (Gasoline) Skill Definition	2
.1	Skill Level 1	
.01	Test cylinder compression	3
.02	Remove, replace, and adjust ignition system components	4
.03	Remove, replace, and adjust fuel system components	5
.04	Adjust valves	6
.2	Skill Level 2	
.01	Test, diagnose, and rebuild fuel systems	7
.02	Test, diagnose, and rebuild ignition systems	8
.03	Test, diagnose, and rebuild governors	10
.04	Test, clean, and adjust pollution control systems	11
.05	Perform final tune-up adjustments	12
.3	Skill Level 3	
.01	Conduct test with dynamometers	13

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Figure 2-6. — Title page of the PRCP Interviewer's Standards and Guides.

SKILL DEFINITION

332 - Engine Tune-up (Gasoline)

NOTE: Skill Levels include all gasoline engines of the reciprocating internal combustion types.

Skill Level 1: Individual must perform the following skills using the appropriate tools and equipment: Remove and replace ignition and fuel system component assemblies: clean and regap spark plugs; remove and replace distributor points, condenser, and vacuum advance unit; adjust point gap using a thickness gauge; adjust valve tappet clearances; adjust ignition timing using a timing light; and take, record, and evaluate cylinder compression readings.

Applicable Training: "A" School

332.1 - Engine Tune-up (Gasoline) I

Skill Level 2: Skill Level 2 plus perform the following skills using the appropriate tools and testing equipment: Disassemble, clean, inspect, repair, adjust, and assemble various types of carburators, fuel pumps, distributors, magnitoes, governors, and air pollution control components; take, record, and interpret fuel and vacuum pump pressures; use and engine analizer to test for, diagnose, and isolate ignition and fuel system malfunctions.

Applicable Training: 332.2 - Engine Tune-up (Gasoline) II

Skill Level 3: Skill Level 2 plus use engine and chassis dynamometers to test for, diagnose, and isolate engine operational malfunctions and prepare dynamometer test reports.

Applicable Training: 332.3 - Engine Tune-up (Gasoline) III

Figure 2-7. — Individual Rating Skill Definition.

standard numerical designation and title (332-Engine Tune-Up (Gasoline)), a statement of tasks to be performed at each level, and the identification of training courses whereby the tasks may be learned.

Each skill definition consists of one, two, or three skill levels, depending upon the complexity and number of the tasks. Each level within a given skill is more difficult to attain than the previous one; however, it has no relationship to another skill. For example, a person with Skill Level 1 in Engine Tune-Up (Gasoline) performs comparatively easy tasks, whereas a Skill Level 1 in engine overhaul must perform everything required in that specific area.

The purpose of the skill definition in the Guides is to introduce the skill material to the interviewee. In fact, you begin your interview by reading the skill definition to him. If he says he can do the related work, you may continue with the interview for the skill level; however, if he says he can't do the work, it is obvious that you should go on to some other skill.

Tasks and Task Elements

A TASK is a specific portion of the overall skill level. Some tasks cover relatively broad areas; others are quite specific and brief. Each task is further broken down into several smaller jobs called task elements.

A task element is a basic part of each task. When interviewing, you will use the task elements

332.1.01 TASK: Test Cylinder Compression

.00 For the TASK ELEMENTS listed below:

	Value
A. Describe the sequence of steps of this procedure and explain the reasons for each.	3
B. List significant tools/equipment used in this procedure.	2
C. Discuss the parameters of this procedure.	2
D. Describe indications that would be observed during this procedure.	3
E. Describe assistance required while performing this procedure.	1
F. Explain results if this procedure is not performed properly or it is neglected.	4
G. Discuss safety precautions to be observed.	3
H. Perform the steps of this procedure when practical.	5

	TASK ELEMENTS:	A	B	C	D	E	F	G	H	T
.01	Remove spark plugs.	3	2				4		5	14
.02	Take and record reading (Dry).	3	2	2	3	1	4	3	5	23
.03	Take and record reading (Wet).	3	2	2	3	1	4	3	5	23
.04	Evaluate readings.	3		2	3					8
									Possible	68
									Qualifying Score	40

Figure 2-8.—Typical Task Analysis with Task Elements and Related Action Statements.

and their related ACTION STATEMENTS to determine the interviewee's qualifications.

Action statements tell you the type of information you should get from the man being interviewed. Each action statement is identified in the Guides by a capital letter (A, B, C, etc). The number of statements varies from task to task. The first action statement in figure 2-8 is:

A. Describe the sequence of steps of this procedure and explain the reasons for each.

Note that each action statement is assigned a numerical VALUE. The value of each ranges from one (1) to (5), depending on its relative importance to the discussion it will produce during the interview. The TOTAL value of all action statements applied to a particular task is called the POSSIBLE score and the total required to qualify an interviewee is called the QUALIFYING score.

STEPS FOR INTERVIEWING

When interviewing, the first thing you should do is to attempt to put the interviewee at ease. A good way of doing this is to explain the purpose of the interview. For example, the interview will:

a. Let the man know what he is actually expected to know and to do.

b. Determine what the man can actually do so that he can be assigned to the right job.

c. Determine the man's deficiencies so that he can be programmed to receive proper training.

Next, explain to the interviewee that he should discuss what he knows of the skill honestly and that he should not be embarrassed if he doesn't know every item covered in the Guides.

Tell the interviewee what skill and skill level he is being interviewed for. Read the skill definition, as was suggested previously, to see if the man is knowledgeable of the subject.

Task Interviewing

Begin interviewing by reading the task. This helps the man to concentrate in the right area. This task should be rephrased: "The first thing we will discuss in Engine Tune-Up (Gasoline) is testing cylinder compression. Then read the first TASK ELEMENT (.01 Remove Spark Plugs). By applying it through ACTION STATEMENT "A" (Describe the sequence of steps of this procedure and explain the reasons for each), it would sound something like this:

"Describe the sequence of steps for removing spark plugs on the gasoline engine and explain the reason for each step."

As you can see, this is not a question. It is a statement directing the man to tell you what he knows about performing the steps of removing spark plugs and the reasons for performing them. There are no questions in the PRCP Interviewer's Standards and Guides; therefore, no answers are provided. The Guides point out the areas to be discussed (in terms of task elements and action statements), and the interviewee's replies are evaluated by the interviewer on the basis of his own personal experience, knowledge, and judgment.

It should be obvious now why all rating skill interviewers MUST be experienced in the skill for which they will interview. The only way you can determine whether or not the interviewee knows the task element is to thoroughly know it yourself. If you are unfamiliar with, or "rusty" in, any tasks in the Guides, study them thoroughly before attempting to interview anyone. Also, if you do not understand how a particular action statement is used with a task element, you must resolve this before interviewing. Discuss the problem with others who are familiar with the skill.

ONLY discuss the task element with the action statements indicated in the columns to their right by the numerical value. For example, in figure 2-8, only action statements "A", "B", "F", and "G" are used with task elements .01. And, in task element .04, only action statements "A", "C", and "G" are applied. As an expert in the skill, you will probably have a desire to "ask questions" in tasks not covered by the Guides. This must be avoided as then there will be no standard. If you feel strongly that the Guides can be improved, discuss your recommendation with the PRCP coordinator.

Scoring Interviews

If the interviewee discusses the task element to your satisfaction, award him the numerical value of the applicable action statement. Do not award partial values. He either knows that part of the task element to which the action statement is applied or he does not.

Continue to discuss all the task elements and action statements with the interviewee where indicated and award values for those you judge he is qualified in. When a task is completed, total up the values awarded. If the total exceeds or equals the qualifying score, certify the man as qualified. Follow the same procedure for the remaining tasks at that skill level.

A man must qualify in each task of a given skill level in order to qualify for that level. Once a man has been assigned a Skill Level 1, he may then be interviewed for Skill Level 2, and so on.

The scores, as such, are only used to determine whether or not the man is qualified to a given level and only the actual level received is entered to the transcript master mentioned earlier.

Do the scoring as you proceed with the interview. Be sure to tell the man how he is doing. If time permits, go over weak points with him and recommend how he can improve his technique and knowledge. A record of the interview provides a good basis for local training programs. For example, if several of your men don't know or have forgotten how to remove spark plugs on a gasoline engine, you can set up a short training session to teach them on the actual equipment.

CHECKING OUT PRACTICAL FACTORS

Before any member of your crew can take the servicewide examination for advancement,

there must be an entry in his service record to show that he has qualified in the practical factors of both the military qualifications and the occupational qualifications. A form known as the RECORD OF PRACTICAL FACTORS, NAVEDTRA 1414/1, is used to record the satisfactory completion of the practical factors, both military and occupational, listed in the Quals Manual. Whenever a crewmember demonstrates his ability to perform a practical factor, appropriate entries should be made in the DATE and INITIALS columns by his immediate supervisor or company officer.

As a CM1 or CMC, you may often be required to check the practical factor performance of lower rated men and to report the results to your company officer. If you had actually observed a man on a job doing precisely what the qualifications call for, you could certify that he has demonstrated his ability. On the other hand, the work situation may never offer an opportunity for a man to demonstrate his ability to perform a particular factor by actual performance. Fortunately, there is at least one way you can resolve the problem. You can develop some practical factor tests of your own. There may be defects, of course, in what you set up, because there is no entirely satisfactory substitute for the real thing.

Using practical factor tests for all practical factors in which a man must be checked out may require much time and effort, but it is one way you can fulfill your responsibilities as an instructor-supervisor. You will, of course, have to discuss your proposals for conducting practical factor tests with your company commander and with others in the battalion who are responsible for the administration of the training program.

Now, for instance, suppose you have to check a man out in the practical factor "Inspect work areas, tools, and equipment to detect potentially hazardous and unsafe conditions and take corrective action" and you have not had the opportunity to observe the man performing this practical factor. One example of a self-made practical factor test for checking out the man in this practical factor follows:

A. OBJECTIVE:

To test the trainee's ability to inspect work areas, tools, and equipment to detect potentially hazardous and unsafe conditions and take corrective action.

B. ESTIMATED TIME FOR TEST: 1 hour

C. MATERIALS:

Construction Mechanic 3 & 2, NAVPERS 10644-F
Construction Mechanic 1 & C, NAVEDTRA 10645-E
Naval Construction Force Safety Manual, COMCBPAC/COMCBLANTINST 5100.1
Local safety regulations, instructions, and directives
Personal protective apparel

D. DIRECTIONS TO THE SUPERVISOR:

Select the work area to be inspected, inform the trainee of your selection, and have him review applicable sections of the publications, regulations, instruction and directives listed in section C above. Allow adequate time and opportunity for the trainee to become familiar with the material before commencing the test. Test the trainee's ability to inspect work areas, tools, and equipment for potentially hazardous and unsafe conditions and take corrective action.

E. TEST:

	PASSED	FAILED
Did the trainee satisfactorily:		
1. Select and utilize protective apparel appropriate for the work areas being inspected?	_____	_____
2. Inspect the following for potentially hazardous and unsafe conditions?	_____	_____
a. Work areas?	_____	_____
b. Tools?	_____	_____
c. Equipment?	_____	_____
3. Ensure that personnel wore appropriate protective apparel and observe all applicable safety precautions in the performance of their duties?	_____	_____
4. Ensure that tools and equipment were being		

Practical Factor (Continued)	PASSED	FAILED
used only for their intended purpose and in the manner prescribed?	_____	_____
5. Take the proper corrective action with respect to potentially hazardous and/or unsafe conditions detected during the inspection of		
a. Work areas?	_____	_____
b. Tools?	_____	_____
c. Equipment?	_____	_____
6. Maintain records and/or reports as required?	_____	_____

The test score will vary according to the practical factor and the emphasis that you think should be placed on each item completed. If the trainee observes all the precautions above, to your satisfaction, then he should be qualified in that particular practical factor.

CHAPTER 3

PW TRANSPORTATION SHOPS SUPERVISOR

A good supervisor must possess a large amount of TACT and DIPLOMACY. Directing shop activities requires that you come in contact with all types of people, i.e., the mechanics who work for you, the personnel (military and/or civilian) who operate the equipment, and the officers to whom you are responsible. You must be very careful not to let prejudices interfere with your good judgment.

A good transportation maintenance shop supervisor will need to call upon all of his past experience. Experience shows up particularly in accurate diagnosis of mechanical troubles; skillful scheduling and planning of repair work, using all kinds of repair equipment; and directing the many activities associated with maintaining transportation and earthmoving equipment.

At sometime during your career in the Navy, you may be assigned as a foreman in a Public Works (PW) transportation maintenance shop. You may also have the occasion to serve as supervisor of a construction battalion equipment maintenance shop. Because of the variation in the two different types of duty, the responsibilities of a foreman in a PW transportation maintenance shop will be discussed in this chapter and the battalion equipment company shops supervisor's responsibilities will be discussed in the following chapter. Although many of the positions have the same basic duties, the methods of accomplishing the work differ considerably in some cases. Also, certain areas of cost control vary a great deal. One important point to consider is that duty in a transportation maintenance shop encompasses work of a continuing nature. Therefore, to promote continuity, civil service personnel are usually employed. On the other hand, in a battalion the work is of a one-time nature for each deployment, and the unit is all military in composition.

PW TRANSPORTATION DEPARTMENT ORGANIZATION

A PW transportation department of a naval shore facility is for all intents and purposes stationary—unlike the mobility of the Alfa Company Shops of an NMCB. As a foreman or supervisor in the PW maintenance division, you would probably not become involved in the planning and construction of a new transportation shop, but would supervise the repair of equipment. However, if you become involved in the establishment of a new base, you will probably be consulted about the location and layout of the maintenance shops. Detailed information on the physical layout of the buildings can be obtained by referring to NAVFAC Publication, P-272, Volume 1, part 1. The location of tools and shop equipment will depend on the amount and type of equipment to be maintained.

The PW transportation organization discussed in this chapter will be typical of the type usually found within a Public Works Activity. The titles and organization may vary from activity to activity. To learn more about these organizations, you should obtain and study current NAVFAC instructions and publications which pertain to Public Work Centers and Public Work Departments. By referring to figure 3-1, you can see that the transportation department is broken down into three divisions; operations, production control, and maintenance. Note that all three come under the control of the transportation superintendent who reports to the Operations Officer. As a CMC or CM1, you would be placed in either the Production Control Division or the Maintenance Division. The job assigned to you will depend on the size of the activity. A small activity may have all divisions combined under a single supervisor/foreman; in a large activity the divisions could be further divided.

DUTIES AND RESPONSIBILITIES OF SUPERVISORY PERSONNEL

This phase of our discussion deals with the duties and responsibilities of various supervisory personnel within the production control and maintenance divisions. Remember that these duties

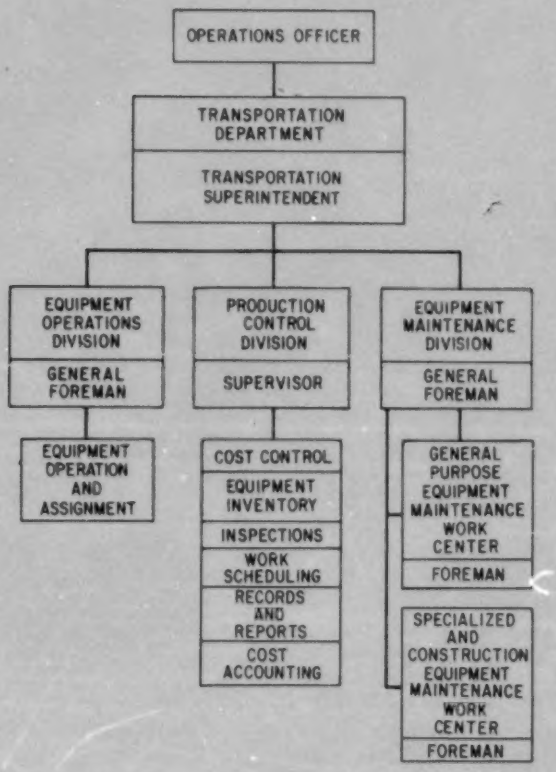

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Figure 3-1.—Typical Public Works Transportation Department organizational chart.

and responsibilities will vary from activity to activity. The individual assignments will depend upon the needs of the activity and the skill and experience of personnel available. The Operations Officer makes the final decision.

TRANSPORTATION SUPERINTENDENT

As head of the Transportation Department, the transportation superintendent exercises full technical, managerial, and administrative responsibility for organizing, directing, and controlling the work of the department and for coordinating operations with other staff and line functions of the Public Works Activity. He also functions as the technical advisor within and outside the activity in planning and procurement of the vehicle/equipment requirements for his activity and other customer commands.

He exercises complete managerial responsibilities for the economical, efficient, and timely administration of the divisions.

He directs Operations assignments; he manages scheduled preventive maintenance as well as repair/overhaul. He is charged with the requisition and disposition of automotive vehicles, construction, materials-weight handling, and various miscellaneous specialized equipment.

PRODUCTION CONTROL SUPERVISOR

The head of the production control division is responsible for receiving, inspecting, and classifying, within applicable Navy codes, all new and used equipment; preparation of reports on equipment received; scheduling equipment into the shop for its initial servicing; and arranging for its inclusion into the preventive maintenance program. Additionally, he must determine parts and tools required to support equipment during its life cycle. He also directs the inspection of vehicles coming into the shop to determine the nature and extent of repair or preventive maintenance service required, and determines the most economical means and method of repairs. He determines the standard hours and cost estimates on individual equipment jobs; initiates shop repair orders; and schedules the work into the various work centers for orderly accomplishment. Finally, he directs the inspection of the mechanics' work while in progress and ensures a quality inspection upon completion of this work. He also directs the maintenance of PM records, shop backlog records, and vehicle history files.

GENERAL FOREMAN

The general foreman, as head of the maintenance division, is responsible for planning, work direction, and administration. He also acts as, and assumes the duties of, the transportation superintendent in his absence. In the maintenance division his responsibilities include:

1. Timely preparation and submission of the maintenance division fiscal financial budgetary requirements.

2. Scheduling of work to be accomplished by subordinate supervisors and planning for the efficient use of materials and equipment.

3. Organizing, coordinating, and directing the work activities of personnel and units being supervised.

4. Maintaining a balanced workload for subordinate work units by shifting personnel among the units for the most effective operation.

5. Coordinating the work in his areas of supervision and with other activities and department/division supervisory personnel in order to maintain a balanced scheduled work flow.

6. Reviewing and analyzing production, cost and personnel utilization records to evaluate the progress of work and to control or reduce costs.

7. Reviewing completed work records (SROs) and other computer reports to assure that production and quality standards are met.

8. Inspecting the shop areas periodically, checking safety conditions, cleanliness, security, requirements for materials, and shop equipment.

9. Acting on any personnel matter concerning his subordinates and assisting in the resolution of grievances referred to him by subordinate supervisors.

10. The promotion of the safety programs within the immediate organization, reviewing the safety performance of the supervisors under him, and initiating corrective action as required.

11. Seeing that necessary progress, production, cost, and other records are prepared, maintained, and consolidated as required.

12. The development of training programs for his employees and subordinate supervisors.

GENERAL PURPOSE EQUIPMENT
WORK CENTER FOREMAN

The foreman or head of the General Purpose Equipment Work Center also supervises subcenters, such as the body and paint shop, battery shop, tire shop, tool room, and lubrication shop. His responsibilities include:

1. Establishing priorities and sequences in which scheduled workload will be accomplished, primarily on a day-to-day/job-by-job basis.

2. Analyzing and interpreting shop repair orders, work requests, and other work documentation and specifications to determine work requirements.

3. Assignment of work among his subordinates and provision of specific material requirements.

4. Consultation with higher authority and staff personnel to make sure that appropriate tools, materials, and equipment are available as needed.

5. Requesting and coordinating the services and work of other shops when required.

6. Assignment of work by written or oral orders.

7. Assists in the training of subordinates in work methods, procedures, and the operation of tools and equipment, both new and already in use.

8. Certification of efficient, economical, and safe production on a continuing basis.

9. Anticipation of operational problems, taking the necessary actions to overcome any delays.

10. Directing and recommending changes in shop layout to improve efficiency.

11. Ensuring that subordinates perform the necessary housecleaning functions.

12. Issuing and enforcing safety practices and fire regulations.

13. Responsibility for attendance and leave of his subordinates, and for other personnel matters.

14. Technical supervision of the entire work center which is responsible for preventive maintenance, major and minor repairs on air and hydraulic brake systems; repair and overhaul of various engines, transmissions, differentials (including rear axles), power take-offs, transfer cases; front end repairs and alignment; metal and body repairs, generator/starter and automotive electrical repairs; complete factory-type spray painting. These and other related automotive repairs might be done on various types of vehicles and equipment, such as sedans, buses, trucks, fire/crash trucks and equipment, ambulances, trash and garbage hauling equipment, and other specialized vehicles and equipment.

CONSTRUCTION AND SPECIALIZED
EQUIPMENT WORK CENTER FOREMAN

The foreman of the Construction and Specialized Equipment Work Center also supervises the machine shop as a subcenter. His responsibilities are basically the same as those given under General Purpose Equipment Work Center Foreman, except for the technical supervision of his center. This work center is responsible for the maintenance, repair, and major overhaul (mechanical and electrical) of specialized equipment, such as tractors, graders, ditch diggers, bulldozers, road rollers, asphalt machines, farm tractors, jet starters, auxiliary power units, emergency generators and pumps, and aircraft tow-tractors.

His subcenter, the machine shop, bores cylinders; rebuilds all types of gasoline and diesel engines, automatic transmissions, and differentials; and performs other related repairs.

STORAGE, PRESERVATION, AND DEPRESERVATION OF VEHICLES AND EQUIPMENT

There is more to storing vehicles and equipment than merely driving them into open areas, warehouses, or active storage. Vehicles and equipment are considered complex when they are being prepared for storage. All components of the equipment must be considered, as well as the basic unit, to ensure efficient operation, with a minimum amount of work, after storage. The objective of preservation and storage is to provide efficient and economical protection to components and equipment from environmental and mechanical damage during handling, shipment, and storage from the time of original purchase until used. NAVFAC P-90, Preservation, Packaging, Packing of NAVFAC Technical Material, is a good reference for this subject.

There are three levels of preserving and packaging equipment for storage. They are classified as levels A, B, and C.

Level A is that level of preservation that will afford adequate protection against corrosion, deterioration, and physical damage during shipment, handling, indeterminate storage, and worldwide redistribution.

Level B is the degree of preservation and packaging which will afford adequate protection against known conditions which are less hazardous than level A is designed to meet. The use of level B should be based on firmly established knowledge of the shipment and storage conditions to be encountered, and a determination that monetary savings will result. This level requires a higher degree of protection than afforded by level C preservation and packaging.

Level C is that level which will afford adequate protection against corrosion, deterioration, and physical damage during shipment from the supply source to the first receiving activity for immediate use.

The proper level of preservation to be applied depends on the availability of information concerning the probable handling, shipping, storing units, and conditions to which the vehicles and equipment will be subjected prior to ultimate issue to the command. Physical characteristics of the vehicles and equipment must also be considered.

Thorough cleaning by an approved technique comes first in every preservation process. Effectiveness of an applied preservative may be measured by the quality of the surface preparation. It is, therefore, necessary that all corrosion and contaminants be removed prior to application of a preservative.

No single cleaning method or material is suitable for all cleaning situations. The selection of a cleaning method, or combination of methods, is dependent on one or more of the following factors:

1. Material composition of the part.
2. Complexity of construction and assembly.
3. Nature of contaminants as well as extent.
4. Amount and age of equipment.
5. Availability of cleaning materials and equipment.

Steam cleaning is one process suitable for removal of greases, tar, road deposits, and other contaminants. This process is particularly adaptable to parts other than the ENGINE and GEAR CASE EXTERIORS of vehicles and equipment that ordinarily would not be disassembled prior to preservation. Cleaning of engines and gear cases should be accomplished by spraying with a degreasing solvent, allowing for solvent penetration, and, finally, flushing with a clean petroleum solvent or wiping with a clean cloth.

Active storage is that procedure by which complex equipment is maintained in serviceable condition by operating all components for brief periods, at regularly scheduled intervals. Deterioration is prevented or minimized by redistribution of lubricants and reducing the action of friction on surfaces. Only unboxed automotive and construction type equipment is eligible for inclusion in the active storage program.

Material preserved and packaged for storage or shipment requires certain depreservation and servicing operations prior to use. Equipment must be lubricated in accordance with the manufacturer's instructions. Seals and closures should be removed. Housings, casings, and other enclosures should be drained of preservatives and refilled with specified operating fluids prior to operation. Those components that were removed for storage should be reinstalled.

Upon activation, in equipment containing piston-cylinder components—such as internal combustion engines and air compressors—you should rotate the crankshaft slowly with the throttle closed, ignition off, and compression release lever (if so equipped) in START position.

Abrasives should not be used in removing preservatives. Remove blocking, wiring or strapping from clutch levers or pedals secured in a partially disengaged position. Adjust drive belts on which tension has been released. Any

corrosion inhibitor mixed with preservative oil in fuel systems should be flushed from the system.

PREVENTIVE MAINTENANCE

The most important phase of the maintenance system is scheduled periodic preventive maintenance (PM). PM is the systematic inspection, detection, and correction of potential equipment failures before they develop into major defects. The purpose of preventive maintenance is to keep equipment in efficient operating condition at all times.

PM starts with the daily maintenance by the operators assigned to the equipment. It is your responsibility to check periodically to see that the operators are performing their duties. You should work with the operations branch in making recommendations regarding operators' PM. Changes may be necessary in the operators' PM to cope with certain operating conditions. You may need to set up classes of instruction for the operators so that they will become familiar with the right way to maintain their equipment. This is especially desirable when new equipment is received in the activity. If you do set up classes, be sure to coordinate your training periods with the foreman in charge of the equipment operations branch to make sure that you do not interfere with his equipment operating schedules. Also try to have the equipment on hand so you can point out maintenance services that need attention. It is generally better to hold the instructions with small groups and to keep them as informal as possible. Do not forget to stress the importance of operator maintenance on the overall operating efficiency of the equipment.

INSPECTIONS

Vehicles will be inspected periodically by qualified automotive inspection personnel for safety as follows:

Each motor vehicle will be inspected for safety at intervals not to exceed 6 months or 6,000 miles, whichever occurs first. To avoid unnecessary downtime, the safety inspection will be performed at the time of the scheduled serviceability inspection in accordance with the manufacturer's recommendations. This safety inspection will include all the items listed below. All deficiencies uncovered during the safety inspection that affect the safe operation of the vehicle will be corrected prior to returning the vehicle to its operational status.

1. Brakes
   a. Test to see if brakes are in good working order.
   b. Check brake pedal free travel as required.
   c. Remove right front brake drum, inspect for wear or cracking, inspect lining for excessive wear, check wheel cylinders for leaks and deterioration.
   d. Check fluid level and all hydraulic brake lines for leaks.
   e. On air brake systems inspect air brake accessories, all airlines, and air tanks for leaks and deterioration; check air brake instrument controls, air valves, trailer hose, and glad hands.
2. Lights
   a. Check all lights, signals, and reflectors.
   b. Check condition of trailer jumper cable.
   c. Check headlights for proper alignment.
3. Instruments, Controls and Warning Devices
   a. Check all instruments, gages, mirrors, switches, controls, horns, and warning devices for function and damage.
4. Exhaust System
   a. Check muffler, exhaust, and tailpipe connections for leaks.
5. Steering System
   a. Check all steering devices and linkage for wear and damage.
6. Seat Belts
   a. Check all safety belts for wear and correct mounting.
7. Fifth Wheel and Trailer
   a. Check fifth wheel mounting bolts or clamps, and the operation of the safety lock.
   b. Check trailer kingpin for wear or damage.
   c. Check towbars, tongue sockets, and safety chains.
8. Tires
   a. Check all tires for damage and excess wear.
   b. Remove and replace all tires showing 1/16 inch or less of tread.
   c. Check wheel lug nuts for tightness.
9. Windshield Wipers, Glass and Defrosters
   a. Check wipers, glass, and defroster for operation, wear damage, and deterioration.

SERVICES

In addition to the safety inspections described above, service inspections are conducted periodically according to the manufacturers' manuals and lubrication charts. Adjustments and repairs made as a result will usually be limited to those items recommended in the manual or chart, and only to the extent necessary to restore the vehicle to first-class working order. More extensive repairs will be authorized by the inspector only after thorough diagnosis and detection of malfunction, wear, or deterioration. Optional adjustments suggested by the manufacturer, for example, "engine tuneup," will not be made unless there is a specific malfunction reported by the operator and diagnosis is confirmed by the inspector. Adverse local conditions may, however, require certain routine preventive maintenance, such as "tuneups," to prevent hard starting and resultant service calls. In cases such as these, the requirement will be determined by management and the action will be directed by management in writing.

UNSCHEDULED MAINTENANCE SERVICE

Unscheduled maintenance service is the correction of deficiencies reported by the vehicle operator that occur between scheduled safety or other inspection and services prescribed by the manufacturer. Unscheduled maintenance services will generally be limited to the correction of only those specific items reported as being deficient by the operator and confirmed by qualified inspection personnel. Unreported deficiencies observed by the inspector at the time of an unscheduled service and, in particular, those affecting safety will be corrected prior to releasing the vehicle for service.

COST CONTROL

The Navy's cost control system is designed to obtain complete cost data relative to maintenance and operation of automotive, construction, firefighting, railway, weight-handling and materials-handling equipment. Actual performance of maintenance work is compared to hourly standards for such work, as established and published by various manufacturers and the Naval Facilities Engineering Command (NAVFAC), in order to determine efficiency of maintenance operations. The Navy also uses cost control to justify the performance of repairs at its activities.

RECORDS AND REPORTS

In the cost control system all cost accumulated in the maintenance and operation of the equipment are recorded and charged to appropriations and allotments. These costs may be direct or indirect labor and material. They may also include services provided, such as shop stores, utilities, and even building maintenance.

Labor job cards are used to collect all labor costs, direct or indirect, and military pay. A Labor Job Time Card, NAVFAC Form 1950 is shown in figure 3-2, and a Labor Job Card, NAVFAC Form 1955 is shown in figure 3-3. Accounting equipment at the activity dictates the proper form to use; and, in some cases, local labor job cards are used in order to supply data to another program.

In order to evaluate performance and to assist in effective management of transportation maintenance, a series of transportation management reports has been designed which will furnish useful information to management at all levels. These reports are prepared by the accountable fiscal office from the cost records maintained in that office, and from feeder reports prepared by the transportation office. These reports provide the facts required by supervisors to pinpoint deficient areas and should be used as a basis for corrective action.

The objectives of the transportation management reports are to provide:

1. Information on the productivity of maintenance shop personnel (actual versus standard hours).
2. Data on overhead costs.
3. Comparison between activity costs and commercial costs.
4. Comparison between actual direct labor hours expended and established maintenance input standards.
5. Comparison between actual and standard maintenance costs.

Variances indicated in reports frequently require a searching review of detailed shop records to determine the causes. The individual Shop Repair Order, NAVFAC Form 9-11200/3A, shown in figure 3-4, and the "Shop Repair Order" (Continuation Sheet), NAVFAC 9-11200/3B, shown in figure 3-5, contain all of the basic data required for this review.

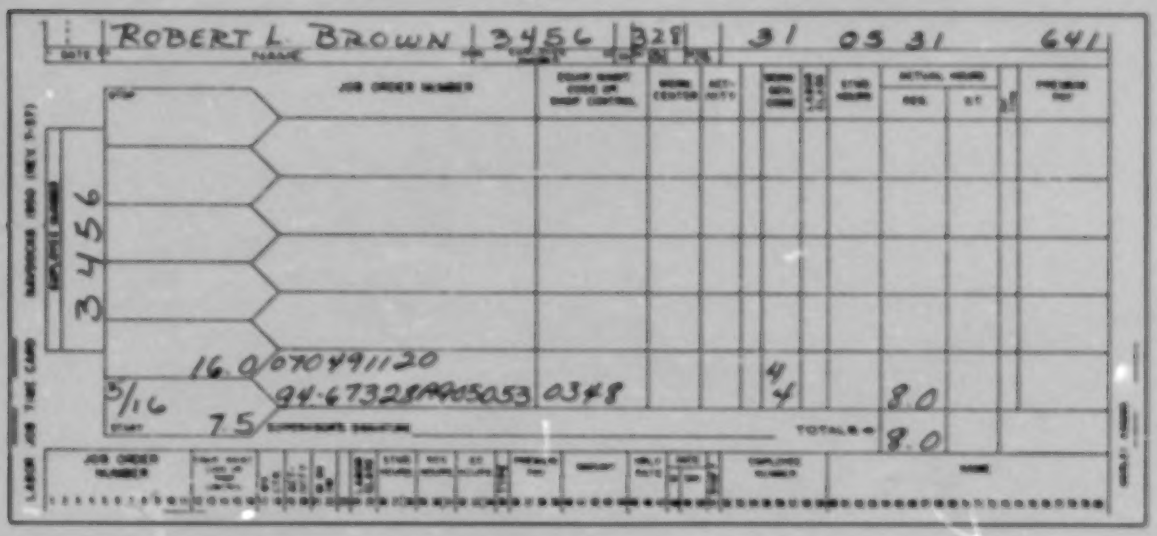

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Figure 3-2.—Labor Job Time Card, NAVFAC Form 1950.

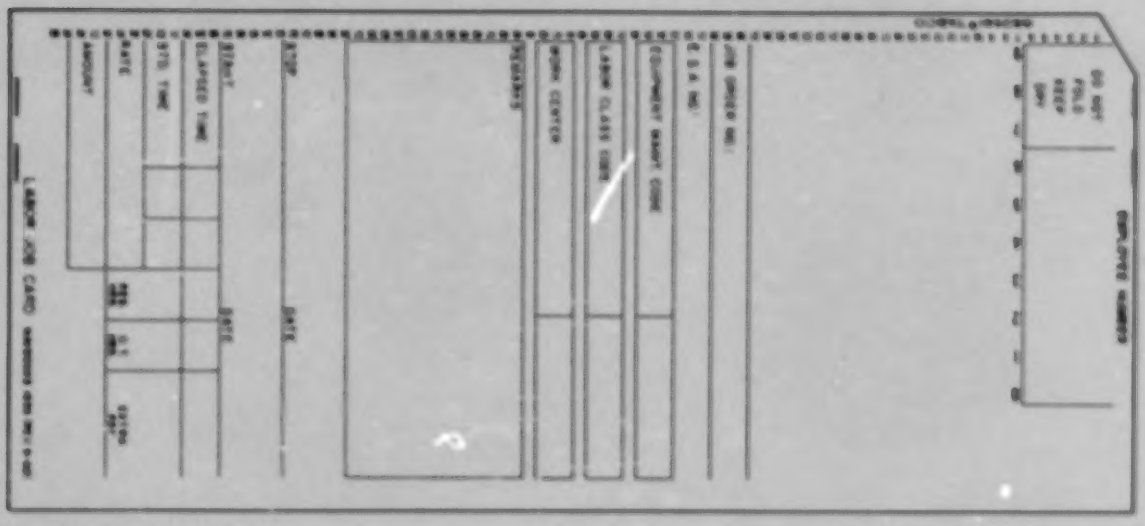

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Figure 3-3.—Labor Job Card, NAVFAC Form 1955.

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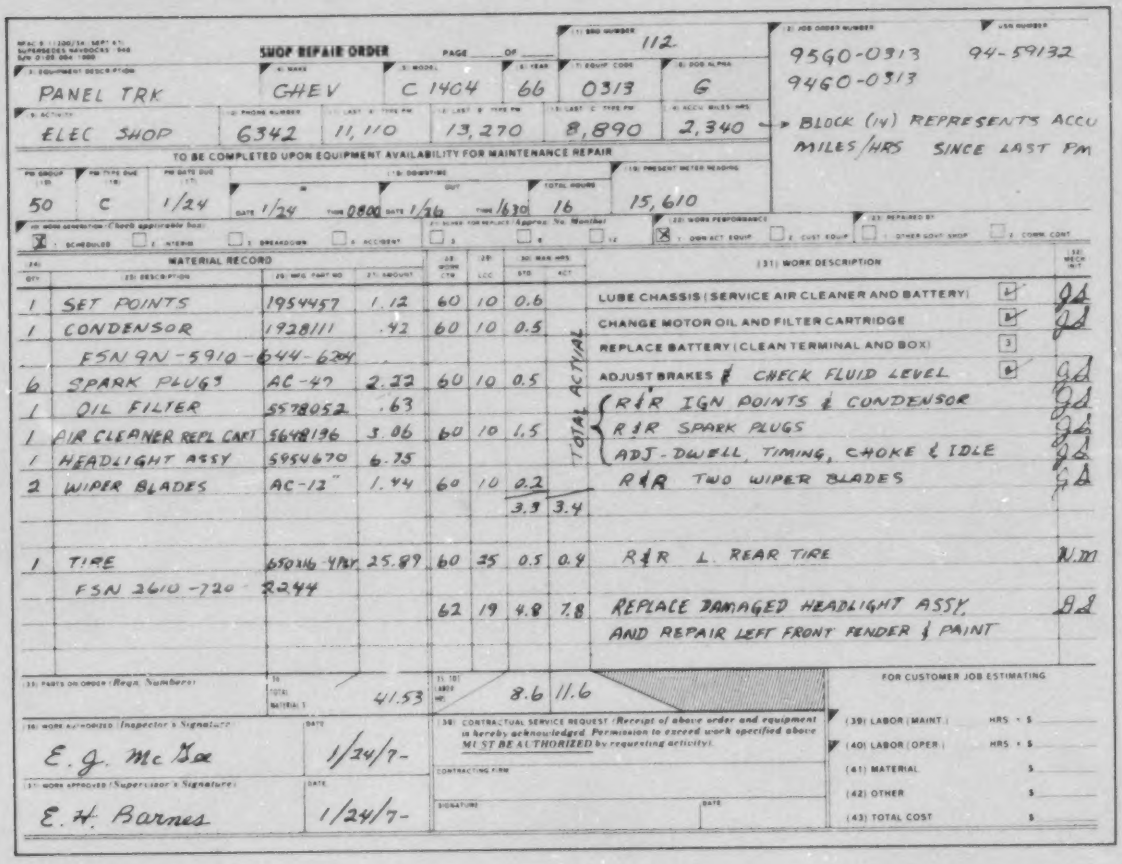


SHOP REPAIR ORDER — PAGE ___ OF ___ — 112

2. EQUIPMENT DESCRIPTION	4. MAKE	5. MODEL	6. YEAR	7. EQUIP CODE	8. JOB ALPHA
PANEL TRK	CHEV	C 1404	66	0313	G

3. JOB ORDER NUMBER: 9560-0313 / 9460-0313 — USN NUMBER: 94-59132

9. ACTIVITY	10. PHONE NUMBER	(12) LAST B TYPE PM	(13) LAST C TYPE PM	14. ACCU MILES/HRS
ELEC SHOP	6342	11,110	13,270	8,890	2,340

→ BLOCK (14) REPRESENTS ACCU MILES/HRS SINCE LAST PM

TO BE COMPLETED UPON EQUIPMENT AVAILABILITY FOR MAINTENANCE REPAIR

15. PM GROUP	16. PM TYPE DUE	17. PM DATE DUE	(18) DOWNTIME IN	(18) DOWNTIME OUT	TOTAL HOURS	19. PRESENT METER READING
50	C	1/24	DATE 1/24 TIME 0800	DATE 1/26 TIME 1630	16	15,610

20. WORK DESCRIPTION: [X] 1 SCHEDULED [ ] 2 INTERIM [ ] 3 BREAKDOWN [ ] 4 ACCIDENT

22. WORK PERFORMANCE: [X] 1 OWN ACT EQUIP [ ] 2 CUST EQUIP [ ] 3 OTHER GOVT SHOP [ ] 4 COMM CONT

23. REPAIRED BY

MATERIAL RECORD

(24) QTY	(25) DESCRIPTION	(26) MFG PART NO	(27) AMOUNT	(28) WORK CTR	(29) LOC	(30) MAN HRS STD	(30) MAN HRS ACT
1	SET POINTS	1954457	1.12	60	10	0.6	
1	CONDENSOR	1928111	.42	60	10	0.5	
	FSN 9N-5910-644-6294						
6	SPARK PLUGS	AC-47	2.22	60	10	0.5	
1	OIL FILTER	5578052	.63				
1	AIR CLEANER REPL CART	5648196	3.06	60	10	1.5	
1	HEADLIGHT ASSY	5954670	6.75				
2	WIPER BLADES	AC-12"	1.44	60	10	0.2	
						3.3	3.4
1	TIRE	650x16 4PR	25.89	60	35	0.5	0.4
	FSN 2610-720-2244						
				62	19	4.8	7.8

(31) WORK DESCRIPTION

LUBE CHASSIS (SERVICE AIR CLEANER AND BATTERY)	4	GA
CHANGE MOTOR OIL AND FILTER CARTRIDGE	4	GA
REPLACE BATTERY (CLEAN TERMINAL AND BOX)	3	
ADJUST BRAKES & CHECK FLUID LEVEL	4	GA
TOTAL ACTUAL: R&R IGN POINTS & CONDENSOR		GA
R&R SPARK PLUGS		GA
ADJ - DWELL, TIMING, CHOKE & IDLE		GA
R&R TWO WIPER BLADES		GA
R&R L. REAR TIRE		WM
REPLACE DAMAGED HEADLIGHT ASSY. AND REPAIR LEFT FRONT FENDER & PAINT		BA

(32) MECH INIT

(33) PARTS OR ORDER (Req. Numbers) — (34) TOTAL MATERIAL $ 41.53 — (35) TOTAL LABOR HRS 8.6 11.6

FOR CUSTOMER JOB ESTIMATING

(36) WORK AUTHORIZED (Inspector's Signature): E. J. McBee — DATE 1/24/7-

(37) WORK APPROVED (Supervisor's Signature): E. H. Barnes — DATE 1/24/7-

(38) CONTRACTUAL SERVICE REQUEST (Receipt of above order and equipment is hereby acknowledged. Permission to exceed work specified above MUST BE AUTHORIZED by requesting activity).
CONTRACTING FIRM
SIGNATURE — DATE

(39) LABOR (MAINT.)	HRS	$
(40) LABOR (OPER.)	HRS	$
(41) MATERIAL		$
(42) OTHER		$
(43) TOTAL COST		$

2.466

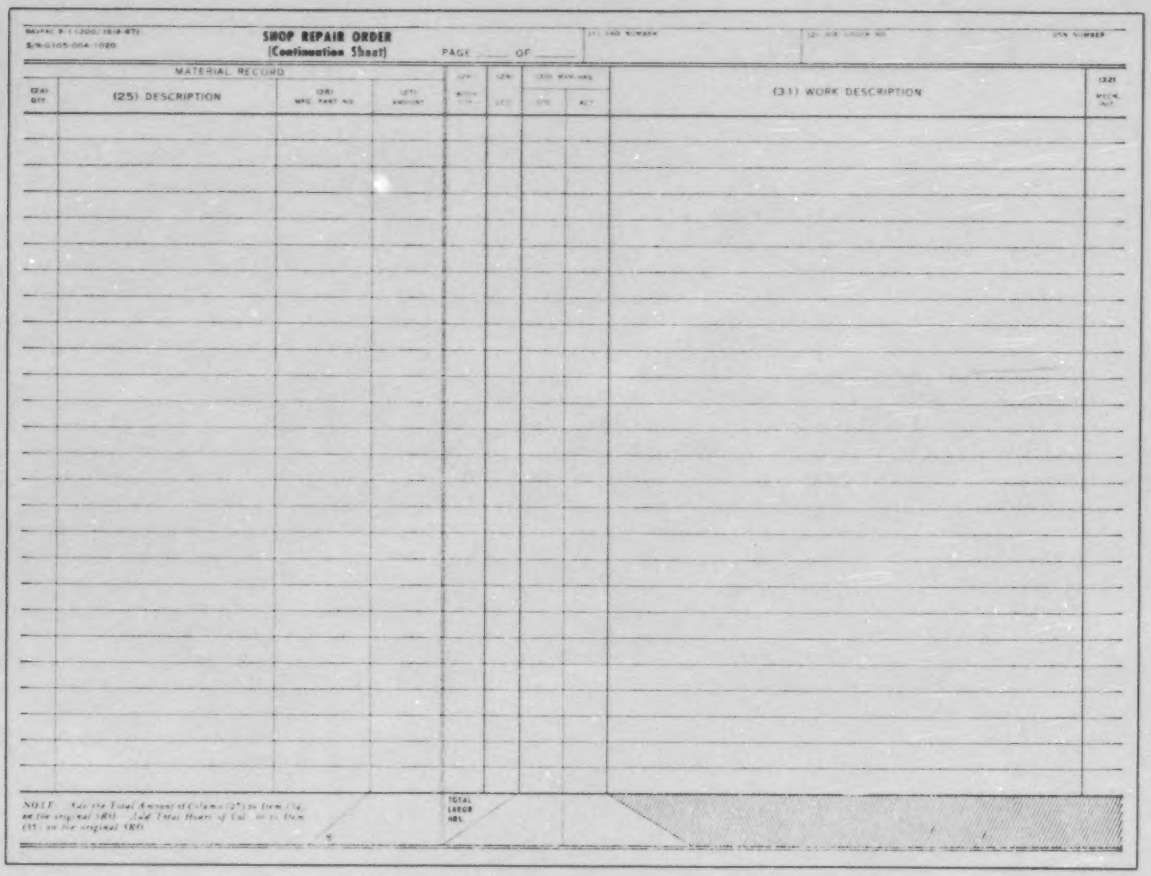
Figure 3-4.—Shop Repair Order, NAVFAC 9-11200/3A.

DEPTH OF MAINTENANCE, REPAIR, AND OVERHAUL

The depth of maintenance, repair, and overhaul is governed by many factors, but the key factor is economics—that is, to provide the best service available at the least possible cost.

The geographic location of an activity bears heavily on the depth of maintenance, repair, and overhaul which a maintenance shop must perform. Maintenance costs must be comparable with national standards. It is easy to see that an activity near a large city, where many repair services are available at commercial shops, is limited as to the type of repairs allowed. Due to the large volume of work involved, many of these specialized commercial shops can perform services at a reduced cost. When the commercial shop is nearby, there are no appreciable transportation or shipping costs to be added to the cost of repairs. On the other hand, an activity located a great distance from commercial sources of repair services and supplies would be able to justify doing its own major repairs due to the time, need, and shipping charges involved in having the work done outside.

The size of an activity also governs the amount and depth of maintenance, repair, and overhaul services. Here, volume is the determining factor that reduces the maintenance cost



SHOP REPAIR ORDER
(Continuation Sheet)
PAGE ____ OF ____

MATERIAL RECORD

(24) QTY	(25) DESCRIPTION	(26) MFG PART NO	(27) AMOUNT

(29) ACTION TYPE	(30) LABOR CLASS	(32) MAN-HOURS EST	(32) MAN-HOURS ACT	(31) WORK DESCRIPTION	(33) WORK UNIT

NOTE — Add the Total Amount of Column (27) to Item 13g on the original SRO. Add Total Hours of Col. (32), Item (33) on the original SRO.

TOTAL LABOR HRS.

2.8.2

Figure 3-5.—Shop Repair Order (Continuation Sheet), NAVFAC Form 9-11200/3B.

to a level comparable with available commercial facilities.

COST JUSTIFICATION

It is easy to see that the Navy system of preventive maintenance, when implemented by the cost control system with its various accounting procedures and reports, is a continuing justification for the transportation maintenance shop's existence. When the needs of the service due to work of a highly classified nature or an extreme geographic location are not an overriding factor, this cost justification is mandatory.

The important thing to remember is that the mere fact that repairs are required is not of itself justification for performance of the repair services by the station maintenance shop.

CHAPTER 4

BATTALION EQUIPMENT COMPANY SHOPS SUPERVISOR

In a Naval Mobile Construction Battalion (NMCB), the equipment maintenance branch is composed of four sections; administration, automotive repair, heavy equipment repair, and support. These sections come under the overall supervision of the maintenance supervisor who is normally a CMCS. As a CM1 or CMC, you may be assigned as an inspector or supervisor in any one of the four sections within the maintenance branch.

In your role as a supervisor or inspector, you will not only need to call upon all of your past experience, but you will have to be constantly alert for new ideas and ways of accomplishing your mission within the time allotted. Of course, skillful predeployment planning is essential; but deployments rarely go according to plans, especially with equipment maintenance. In addition to facing unusual maintenance problems not encountered at a Public Works duty station, you must be ready to pack your gear and mount out at any given moment.

The chapter will describe the duties and responsibilities you will be expected to perform when assigned to a section.

This chapter will cover the composition of the different sections as well as the duties and responsibilities you will be expected to perform when assigned to any one of the sections. Remember that these duties and responsibilities will vary from battalion to battalion; assignments are made by the maintenance supervisor.

One of the most important tasks is to stay abreast of developments in equipment maintenance. Here are publications to consult that will help you keep up to date: the COMCBPAC/COMCBLANT and NAVFAC Instructions 11200 series; Naval Construction Force Safety Manual (COMCBPAC/COMCBLANT Instruction 5100.1 series); Naval Construction Force Manual, NAVFAC P-315; Equipment Officer Technical Bulletins; and Modification Work Orders.

SETTING UP A MAINTENANCE BRANCH

Due to the mobility of an NMCB, you will be required to assist the maintenance supervisor in planning for the location, construction, and layout of the maintenance branch.

Remember that the maintenance shops should be close to the transportation facilities. In addition, the site chosen should be large enough to allow for expansion and have a large area for parking various vehicles which are deadlined or awaiting PMs or repair. The number and types of vehicles to be maintained are important in laying out the shop. You can get more information on the physical arrangement of the buildings from the Facilities Planning Guide, NAVFAC P-437.

TOOLS AND EQUIPMENT

The quantities and kinds of tools and equipment required for a maintenance shop will vary with each shop. In deciding what tools and what type of equipment to have on hand, consider two factors: (1) the operational needs of the battalion and (2) cost of the work at a component overhaul facility. Of course, the needs of the service come first, but not entirely without cost justification. Base your decision concerning the second factor solely on the facts and figures given in transportation maintenance management reports.

In a maintenance shop set up for repairing all types of equipment, you will coordinate and supervise work on many different types; therefore, study carefully the layout of the shop and the placement of shop equipment. Decisions on where to put shop equipment will probably be yours. This is where experience counts. You should know where the repair equipment is needed and where it will be accessible to the men who will use it. Without careful planning you can waste a lot of space, and time in shifting equipment from one place to another. If space in

the main shop is critical, special repair equipment can be put in smaller shops or rooms adjoining the main shop.

Power tools, such as drill presses and bench grinders commonly used in repairing all kinds of equipment, should be located in or near the main shop area. The locations of other power tools, such as hydraulic or electric lifts, valve grinders, and machines for aligning wheels and relining brakes, depend on where the tools will be best utilized. The master switch that controls all power in the shop should be installed where it can be reached quickly in an emergency.

In placing power tools, secure the legs or bases to a level surface strong enough to support them and make sure they will not move or bounce when in use. Before connecting stationary, electrically operated power tools to power outlets, be sure that each one is positioned so that the starting and stopping switch is within easy reach of the operator. When the connection is complete, test the tools to ensure that the installation is safe. Also, let your men operate them and consider any suggestions they may have for improvements. As always, make sure your tool and equipment operators wear protective gear. Double check often, looking for ways to improve the efficiency as well as the safety of the whole maintenance shop.

Welding equipment must be operated in an area apart from the rest of the shop. Post hazard warning signs in the area and equip it with firefighting apparatus. Erect screens to confine flying sparks and reduce their chances of starting fires or getting into somebody's eyes.

Tire repair equipment should also be in a separate section of the shop located near one of the shop entrances. With this arrangement, tire tools, tube patching equipment, and air-hoses can be used by the EO as readily as by the CM.

Before deciding where to place an air compressor, (the large shops have more than one), consider the uses you have for air and where the air outlets would be most convenient. Compressed air is needed for operating pneumatic power tools, cleaning parts, and inflating tires. By keeping compressor lines as short and bend-free as possible you minimize drops in air pressure at the outlets. Short lines do not collect as much water as long lines and are less likely to freeze in cold weather. When you have long lines, install condensation traps in them and drain the traps daily.

Battery charging equipment must be in a well ventilated section of the shop, or in a separate building. Because fumes of hydrogen produced by a changing battery are highly explosive, always install an exhaust fan near the battery charger. Also make sure a water outlet is handy so that anyone involved in a battery shop accident can be bathed immediately to prevent severe burns. Delay in diluting or washing out sulphuric acid from a victim's eyes could result in loss of sight.

SAFETY

Safety is everyone's responsibility. It is a never ending job that cannot be left to an individual or an office. Everyone must always be alert to accident prevention. You must emphasize safe working practices to the point where they are routine.

One of the basic rules of shop safety requires that everyone behaves himself. Practical jokes and horseplay cannot be tolerated. The possible consequences of such actions are too high a price to pay for the little humor derived.

You can help prevent accidents by appointing a shop safety man to detect unsafe practices, bad habits, and defective tools that would otherwise go unnoticed. Also, replace your shop safety man periodically, thereby rotating his duties.

The number of personal injuries in a shop can be reduced through good housekeeping practices. For example, keeping the shop floor free of grease and oil spots to help prevent mechanics and others from slipping or falling. Likewise, clearing the floor of creepers, stray tools, and parts to eliminate the chances of tripping over them. Curing bad habits will also cut down on injuries. Crack down on bad habits, such as leaving jack handles stick out into walkways and leaving vehicle doors open while men work underneath.

HEAT, LIGHT, AND VENTILATION

Heat, light, and ventilation for a large, permanent maintenance shop are included in the plan specifications. However, the installation of these facilities in the small or temporary shop will depend on the supervisor.

Whether or not you will heat your shop depends upon its geographical location. Heaters should be arranged to provide warmth where it is most needed. Persons working at benches or in the shop store require more heat than men working in the main shop for comparatively

short periods. For this reason, heaters are placed in corners convenient to work benches and away from shop doors.

For adequate lighting, most maintenance shops depend upon lights arranged in the overhead of the main shop, lights and windows near the work benches, and extension lights that can be plugged into electrical outlets. When you are in charge of setting up a maintenance shop, make sure that enough electrical outlets are provided for extension lights and electric power tools. Only the most elaborate shops have enough windows for efficient lighting.

Removing exhaust gases becomes a big problem in every maintenance shop. Large doors in the front and rear of the shop, and windows at the work benches will normally supply all the fresh air needed, but even these are inadequate to remove excessive amounts of exhaust gases. These gases rise and are trapped in the shop overhead unless roof openings with ventilating fans are provided. Normally it is up to the supervisor of a temporary shop to provide his own method of ventilation. A piece of flexible steel or neoprene hose, attached to the exhaust on a running engine, and carried outdoors through an opening in the building will serve the purpose. Do not allow any unnecessary operation of an engine inside the shop.

When stationary gasoline or diesel engines are used to produce power in the maintenance shop, provide exhaust outlets for them. Do not depend on natural ventilation through doors and windows.

MAINTENANCE SUPERVISOR

The maintenance supervisor, usually a CMCS, has direct control over the administration section. He is responsible for the maintenance and repair of all automotive, construction, and materials-handling equipment assigned to the battalion or Naval Construction Force (NCF) unit. Specifically, his duties and responsibilities include:

1. Control and supervision of all maintenance personnel.

2. Ensuring adherence to the scheduled preventive maintenance program.

3. Ensuring accurate cost control, record maintenance, and updating.

4. Submitting equipment reports to the Alfa Company Commander and the commanding officer for distribution to higher authority.

5. Maintaining the construction mechanics' tool allowance and conducting bi-weekly tool inventories.

6. Providing technical and safety training.

7. Providing technical assistance to the supply and logistics officer with regard to repair parts.

8. Ensuring quality control of the repair and maintenance work.

9. Ensuring that the Battalion Equipment Evaluation Program is carried out in accordance with the latest instructions.

SHOP INSPECTOR

The shop inspector is normally a CM1 who works directly for the maintenance supervisor performing inspections on equipment needing service. Each shop inspector is a seasoned mechanic capable of determining readily the nature of the necessary repairs on any piece of equipment. He decides whether to give the equipment immediate attention or to delay until the next scheduled PM inspection and service. Before inspecting a piece of equipment, the shop inspector checks the file of operators inspection guide and trouble reports. As part of the inspection, he completes appropriate record forms and notes deficiencies clearly on the equipment work order (EWO). He also performs minor adjustments incidental to the inspection.

The EWO is delivered first to the cost control clerk for information on spare parts which have been received or are on order to prevent reorders. Then the EWO is delivered to the maintenance supervisor for work approval and assignment. After repair or overhaul, the shop inspector performs a final inspection, after final inspection he recommends to the shop supervisor that the equipment be released to full service.

AUTOMOTIVE REPAIR SUPERVISOR

The automotive shop supervisor has direct control over the automotive repair section. Normally a CMC, he works directly for the maintenance supervisor. Among his duties are:

1. Control and supervision of all maintenance personnel assigned to his shop.

2. Ensuring that preventive maintenance is performed in accordance with current instructions.

3. Submitting accurate maintenance records to the cost control section.

4. Maintaining the mechanics' tool kits and conducting required inventories.

5. Providing necessary technical and safety instruction and leadership.

6. Ensuring all work listed on EWOs is performed and that any additional work is recorded and performed.

7. Ensuring that only top quality work is performed in his shop.

HEAVY EQUIPMENT
REPAIR SUPERVISOR

The heavy shop supervisor has direct control over the heavy equipment repair section. Usually a CMC, he works directly for the maintenance supervisor. In addition to the duties of the automotive repair supervisor just listed, the heavy shop supervisor is responsible for the assignment and supervision of the field maintenance crew.

The importance of field maintenance and field repairs cannot be overemphasized. The success or failure of the deployment from an equipment maintenance standpoint, and in some cases from the project standpoint, can be traced to unavailability of equipment due to poor field maintenance or inability to perform adequate and timely repairs in the field. Experienced field mechanics are worth their weight in gold, and the heavy shop supervisor must be careful in his selection of the field mechanics, even to the point of shortchanging himself in the shop. In the long run, good field maintenance will reduce the shop workload and improve the operator's concern for his equipment. Remember, it is the responsibility of the heavy shop supervisor to provide the tools and equipment required by the field mechanics.

SUPPORT SECTION SUPERVISOR

The support section supervisor is normally a CM1 or CMC, and reports directly to the maintenance supervisor. He is responsible for training, supervising, and controlling the support functions assigned him by the maintenance supervisor. The support section normally includes the tool room and shops described in the following paragraphs. All these shops perform their services to support the heavy and automotive repair shops which have the basic maintenance responsibility for all the equipment assigned to the battalion.

Mechanics' Toolroom

The mechanics' toolroom is the central point for issue, storage, inspection, maintenance and repair of all mechanics' tools under an approved custody control system. The shop supervisor is the custodian of Kits and tools needed continuously which are checked out by the mechanics on custody receipts. Other tools are issued on tool chits for particular job assignments. The toolroom personnel perform tool repair within their capability, and request assistance of other battalion shops when necessary.

Machine Shop

Machinery Repairmen (MR) are assigned to operate the machine shop trailer which contains lathes, drill presses, grinders, and other machine tools. The MRs are capable of manufacturing or repairing equipment parts, tools, and machine parts.

The machine shop trailer should be located near the repair shops to make it convenient for the men of both shops to work together on joint projects.

Chassis, Body, Fender,
and Radiator Shop

In most battalions Steelworkers (SW) and Hull Technicians (HT) form the nucleus of this shop. Their work includes repairing or rebuilding chassis components, fenders, and other body parts; repairing, rebuilding, and testing radiators; repairing crane booms, bulldozer blades, and other steel components; and welding and brazing.

Electrical Shop

Manned by Construction Mechanics, the electrical shop repairs, rebuilds, cleans, adjusts, and tests all automotive electrical parts and accessories, such as generators, starters, and voltage regulators.

Battery Shop

Men assigned to the battery shop rebuild, maintain, and recharge wet cell batteries, mix electrolyte, disassemble, and reassemble used batteries and keep a supply of fully charged, spare batteries for equipment used by the battalion.

The battery shop should include space for the repair and recharging of batteries. Be sure that battery chargers are located in a well ventilated area to dissipate the fumes given off during charging, and that they include adequate safety equipment.

Tire Shop

The Construction Mechanics assigned to the tire shop repairs and replaces the pneumatic tires in the battalion.

Normally, the tire shop is located in an area that is accessible to all types of equipment utilizing rubber tires which require removal, repair, or replacement from time to time. This shop should be equipped with tire-mounting sets, tools, and air compressor, and other support equipment necessary to complete tire repairs in a reasonable period of time so that the equipment can be returned to the job site with little or no lost time.

Lube Shop

The mechanics assigned to the lubrication racks maintain adequate stocks of all lubricants required by the battalion, and lubricate automotive and construction equipment as required under the Preventive Maintenance Program.

Although you will have trailer-mounted lubricators and lubricating teams for servicing equipment in the field, most of your scheduled PMs will be accomplished in the maintenance shop area. Outdoor locations for lubrication stalls are satisfactory in temperate climates and during favorable weather, but efficiency is increased by providing suitable shelter. PM racks should include provisions for storage of greases and oils, preferably at a distance from your other shop areas, as a precaution against fire. In addition to facilitating lubrication services, these racks should have the added advantage of providing for easier inspection and cleaning of under parts and surfaces of equipment.

The Construction Mechanics responsible for field lubrication should regularly check all construction equipment stationed in the field and lubricate the equipment as required under the Preventive Maintenance Program.

Just as in the case of the field mechanics, top caliber, conscientious personnel should be assigned, since for the most part, they perform their services far away from their shop supervisor.

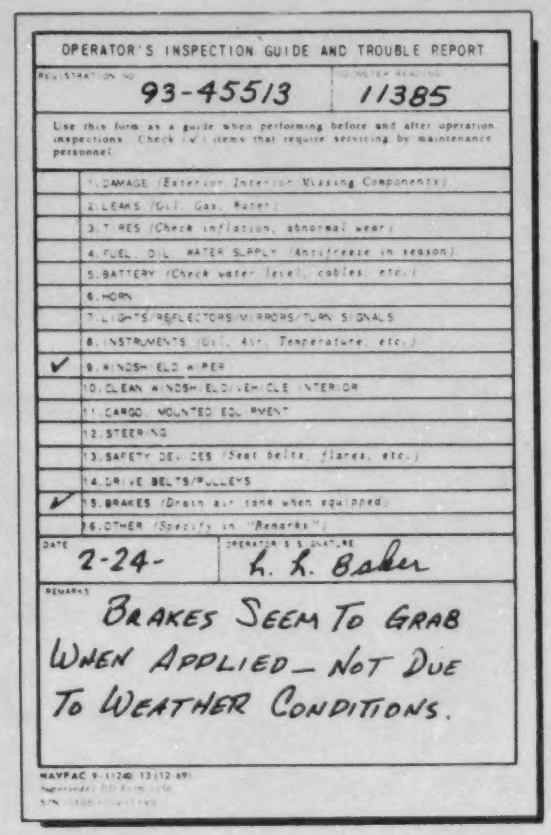
There is sometimes a tendency to overlook another important type of servicing: operator servicing. The point to remember here is that anything that affects your specific area of responsibility automatically becomes a collateral duty. You, as a supervisor, should tactfully initiate action to prevent this collateral area from hindering you in the accomplishment of your principal duties. It may be necessary to institute operator servicing classes, or, in some cases, operator training classes on troublesome pieces of equipment. Remember, tact is the key when you leave your specific area of responsibility to get a job done.

BATTALION MAINTENANCE PROGRAM

The purpose of the maintenance program of a battalion is to keep its automotive and heavy equipment operating and to prevent minor mechanical problems from becoming major ones. The Civil Engineer Support Equipment (CESE) maintenance system of the NCF consists of three levels of maintenance: organizational, intermediate, and depot.

ORGANIZATIONAL MAINTENANCE

The first, or organizational, level of maintenance is divided into two categories: operator maintenance and preventive maintenance (PM). Operator maintenance is that which every operator is required to perform to maintain his equipment in a clean, safe, and serviceable condition. It includes the daily inspections, lubrications, and adjustments necessary to ensure early detection of malfunctions of equipment. Figure 1 and 2 show the preventive maintenance forms which the operator can use as guides for a daily prestart inspection, and as a trouble report in case of any defects or unsafe conditions, which need be reported to the dispatcher immediately. Preventive Maintenance goes beyond



OPERATOR'S INSPECTION GUIDE AND TROUBLE REPORT

REGISTRATION NO. 93-45513 — COUNTER READING 11385

Use this form as a guide when performing before and after operation inspections. Check (✓) items that require servicing by maintenance personnel.

	1. DAMAGE (Exterior, Interior, Missing Components)
	2. LEAKS (Oil, Gas, Water)
	3. TIRES (Check inflation, abnormal wear)
	4. FUEL, OIL, WATER SUPPLY (Antifreeze in season)
	5. BATTERY (Check water level, cables, etc.)
	6. HORN
	7. LIGHTS/REFLECTORS/MIRRORS/TURN SIGNALS
	8. INSTRUMENTS (Oil, Air, Temperature, etc.)
✓	9. WINDSHIELD WIPER
	10. CLEAN WINDSHIELD/VEHICLE INTERIOR
	11. CARGO MOUNTED EQUIPMENT
	12. STEERING
	13. SAFETY DEVICES (Seat belts, flares, etc.)
	14. DRIVE BELTS/PULLEYS
✓	15. BRAKES (Drain air tank when equipped)
	16. OTHER (Specify in "Remarks")

DATE: 2-24- — OPERATOR'S SIGNATURE: L. L. Baker

REMARKS: BRAKES SEEM TO GRAB WHEN APPLIED — NOT DUE TO WEATHER CONDITIONS.

NAVFAC 9-11240/13 (12-69)

29.50

Figure 4-1.—Operator's Inspection Guide and Trouble Report, NAVFAC 9-11240/13.

the inspections, lubrications, and adjustments in operator maintenance. The prime objective of PM is ensuring availability and minimizing unnecessary repair costs. Operators should participate in PM unless specifically directed otherwise.

INTERMEDIATE MAINTENANCE

The maintenance shop whether mobile, semimobile, permanent, or semipermanent has the responsibility of the intermediate level of maintenance. A higher degree of skill is required to accomplish this type of maintenance, since it includes removal, replacement, repair, alteration, calibration, modification, rebuild, and overhaul of individual assemblies, subassemblies, and components.

DEPOT MAINTENANCE

Depot maintenance is performed on a unit of equipment that requires major overhaul or restoration to the degree that will restor the entire unit to like-new condition. During overhaul or rebuild, the lower levels of maintenance are included in depot maintenance.

SCHEDULING MAINTENANCE

The standard interval between PM service inspections for NCF equipment is 40 working days, 2,000 miles, or 120 hours, whichever occurs first. This interval is established initially by grouping all assigned equipment into 40 separate PM groups. The equipment is distributed evenly among the PM groups so that the minimum number of similar items are out of service at any one time.

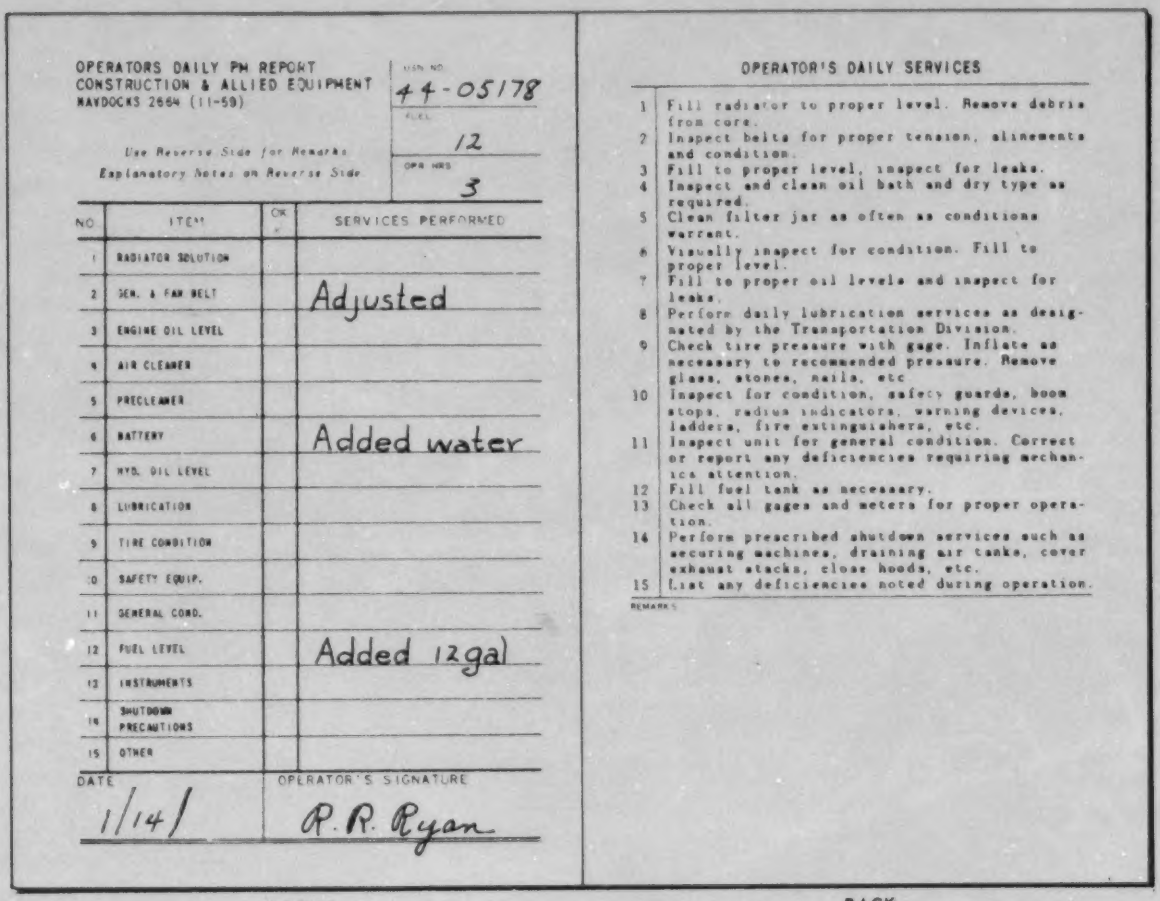
It is the responsibility of the maintenance supervisor to determine whether the PM interval for any item of equipment should be reduced. He can shorten the interval by assigning specific items of equipment to more than one group or reducing the total number of groups. He cannot, however, extend the standard interval between PM service inspections. To establish a deployment schedule of PM due dates, he records the workdays of the month consecutively beside the PM group numbers. See the sample schedule (fig. 4-3).

The types of PM inspection are defined and given as follows:

Type A inspections—Given at intervals of 40 working days, using appropriate PM Services and Inspection Guide. They are performed on scheduled PM due dates until the vehicles qualify for type B inspections.

Type B inspections—Given at intervals of 2,000 miles, 120 hours, or after two consecutive type A inspections, using the appropriate PM Services and Inspection Guide. Engine oil and oil filters are changed.

Type C inspections—Given as required, using the appropriate PM Service and Inspection Guide.



OPERATORS DAILY PM REPORT
CONSTRUCTION & ALLIED EQUIPMENT
NAVDOCKS 2664 (11-59)

USN NO. 44-05178
FUEL 12
OPR HRS 3

Use Reverse Side for Remarks
Explanatory Notes on Reverse Side

NO.	ITEM	OK	SERVICES PERFORMED
1	RADIATOR SOLUTION		
2	GEN. & FAN BELT		Adjusted
3	ENGINE OIL LEVEL		
4	AIR CLEANER		
5	PRECLEANER		
6	BATTERY		Added water
7	HYD. OIL LEVEL		
8	LUBRICATION		
9	TIRE CONDITION		
10	SAFETY EQUIP.		
11	GENERAL COND.		
12	FUEL LEVEL		Added 12 gal
13	INSTRUMENTS		
14	SHUTDOWN PRECAUTIONS		
15	OTHER		

DATE 1/14/ OPERATOR'S SIGNATURE R. R. Ryan

OPERATOR'S DAILY SERVICES

1. Fill radiator to proper level. Remove debris from core.
2. Inspect belts for proper tension, alinements and condition.
3. Fill to proper level, inspect for leaks.
4. Inspect and clean oil bath and dry type as required.
5. Clean filter jar as often as conditions warrant.
6. Visually inspect for condition. Fill to proper level.
7. Fill to proper oil levels and inspect for leaks.
8. Perform daily lubrication services as designated by the Transportation Division.
9. Check tire pressure with gage. Inflate as necessary to recommended pressure. Remove glass, stones, nails, etc.
10. Inspect for condition, safety guards, boom stops, radius indicators, warning devices, ladders, fire extinguishers, etc.
11. Inspect unit for general condition. Correct or report any deficiencies requiring mechanics attention.
12. Fill fuel tank as necessary.
13. Check all gages and meters for proper operation.
14. Perform prescribed shutdown services such as securing machines, draining air tanks, cover exhaust stacks, close hoods, etc.
15. List any deficiencies noted during operation.

REMARKS

FRONT BACK

81.323

Figure 4-2.—Operator's Daily PM Report, Construction and Allied Equipment, NAVFAC Form 2664.

They can be waived by the maintenance supervisor if doing so increases equipment availability without sacrificing equipment condition.

A Preventive Maintenance Record Card (fig. 4-4), is maintained for each item of assigned equipment to help the PM clerk prepare the EWO. The following information is taken from the completed EWO and entered on a record card:

- Type of PM service performed.
- Date performed.
- Cumulative mileage/hours.
- Whether oil or filter was changed (shown by the abbreviation O/C or F/C).

PM Record Cards are maintained by PM group in a tickler file which the maintenance supervisor reviews at least once a month. When a vehicle is transferred, its PM Record Cards are placed in the equipment history jacket.

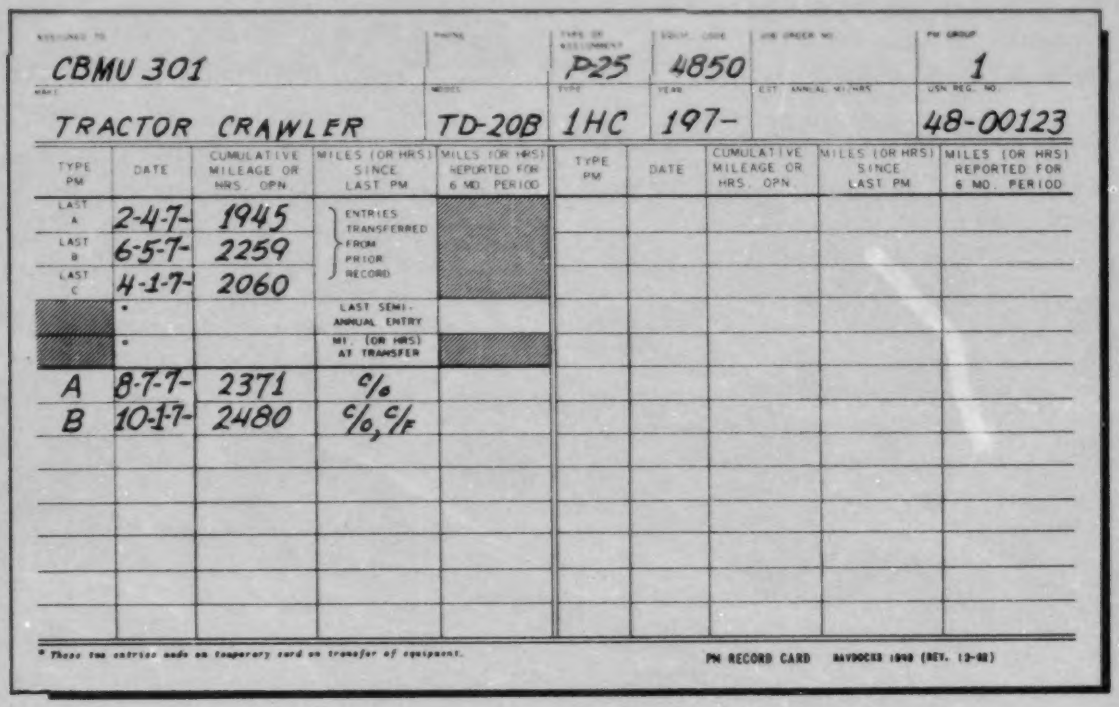
ACTIVITY _____

YEAR _____

PM SCHEDULE GROUP	MONTH AND DAY SCHEDULE											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	21		19		14		11		6		1	
2	22		20		15		12		9		4	
3	23		21		16		15		10		5	
4	24		22		17		16		11		6	
5	25		25		20		17		12		7	
6	28		26		21		18		13		8	
7	29		27		22		19		16		12	
8	30		28		23		22		17		13	
9	31		29		24		23		18		14	
10		1		1	27		24		19		15	
11		4		2	28		25		20		18	
12		5		3	29		26		23		20	
13		6		4	31		29		24		21	
14		7		5		3	30		25		22	
15		8		8		4	31		26		25	
16		11		9		5		1	27		26	
17		12		10		6		2	30		27	
18		13		11		7		5		1	29	
19		14		12		10		6		2		2
20		15		15		11		7		3		3
21		18		16		12		8		4		4
22		19		17		13		9		7		5
23		20		18		14		12		8		6
24		21		19		17		13		9		9
25		25		22		18		14		10		10
26		26		23		19		15		11		11
27		27		24		20		16		14		12
28	2	28		25		21		19		15		13
29	3		1	26		24		20		16		16
30	4		4	29		25		21		17		17
31	7		5	30		26		23		18		18
32	8		6		1	27		26		21		19
33	9		7		2	28		27		22		20
34	10		8		3		1	28		23		21
35	11		11		6		2	29		24		24
36	14		12		7		3	30		25		26
37	15		13		8		5			28		27
38	16		14		9		8		3	29		30
39	17		15		10		9		4	30		31
40	18		18		13		10		5	31		

2.467

Figure 4-3. — PM Schedule.



ASSIGNED TO: CBMU 301 | PHONE | TYPE OF EQUIPMENT: P-25 | EQUIP. CODE: 4850 | JOB ORDER NO. | PM GROUP: 1

NOUN: TRACTOR CRAWLER | MODEL: TD-20B | TYPE: 1HC | YEAR: 197- | EST. ANNUAL MILEAGE/HRS. | USN REG. NO.: 48-00123

TYPE PM	DATE	CUMULATIVE MILEAGE OR HRS. OPN.	MILES (OR HRS) SINCE LAST PM	MILES (OR HRS) REPORTED FOR 6 MO. PERIOD	TYPE PM	DATE	CUMULATIVE MILEAGE OR HRS. OPN.	MILES (OR HRS) SINCE LAST PM	MILES (OR HRS) REPORTED FOR 6 MO. PERIOD
LAST A	2-4-7-	1945	ENTRIES TRANSFERRED FROM PRIOR RECORD						
LAST B	6-5-7-	2259							
LAST C	4-1-7-	2060							
	*		LAST SEMI-ANNUAL ENTRY						
	*		MI. (OR HRS) AT TRANSFER						
A	8-7-7-	2371	C/O						
B	10-1-7-	2480	C/O, C/F						

* These two entries made on temporary card on transfer of equipment.

PM RECORD CARD NAVDOCKS 1949 (REV. 12-42)

2.468

Figure 4-4.—PM Record Card, NAVDOCKS Form 1949.

INSPECTING DEADLINE EQUIPMENT

Deadlined equipment is inspected on its scheduled PM due date, or sooner if determined by the maintenance supervisor. The purpose of the inspection is to ensure that (1) all openings are covered and weathertight, (2) all machine surfaces are preserved, (3) all disassembled components are tagged, covered, and stored, and (4) nothing has been cannibalized. Interchanging of controlled parts is not recommended or approved as a normal procedure, but the maintenance supervisor may authorize it in order to meet operational commitments. In each case, he makes sure that parts removed from deadlined equipment are replaced with nonserviceable parts and replacement parts are requisitioned.

All placement parts cost and labor hours related to the interchange are charged against the piece of equipment on which the part failed making the interchange necessary.

When the requisitioned replacement parts are received, and installed, only the labor involved is charged to the piece of equipment from which the interchanged part was taken.

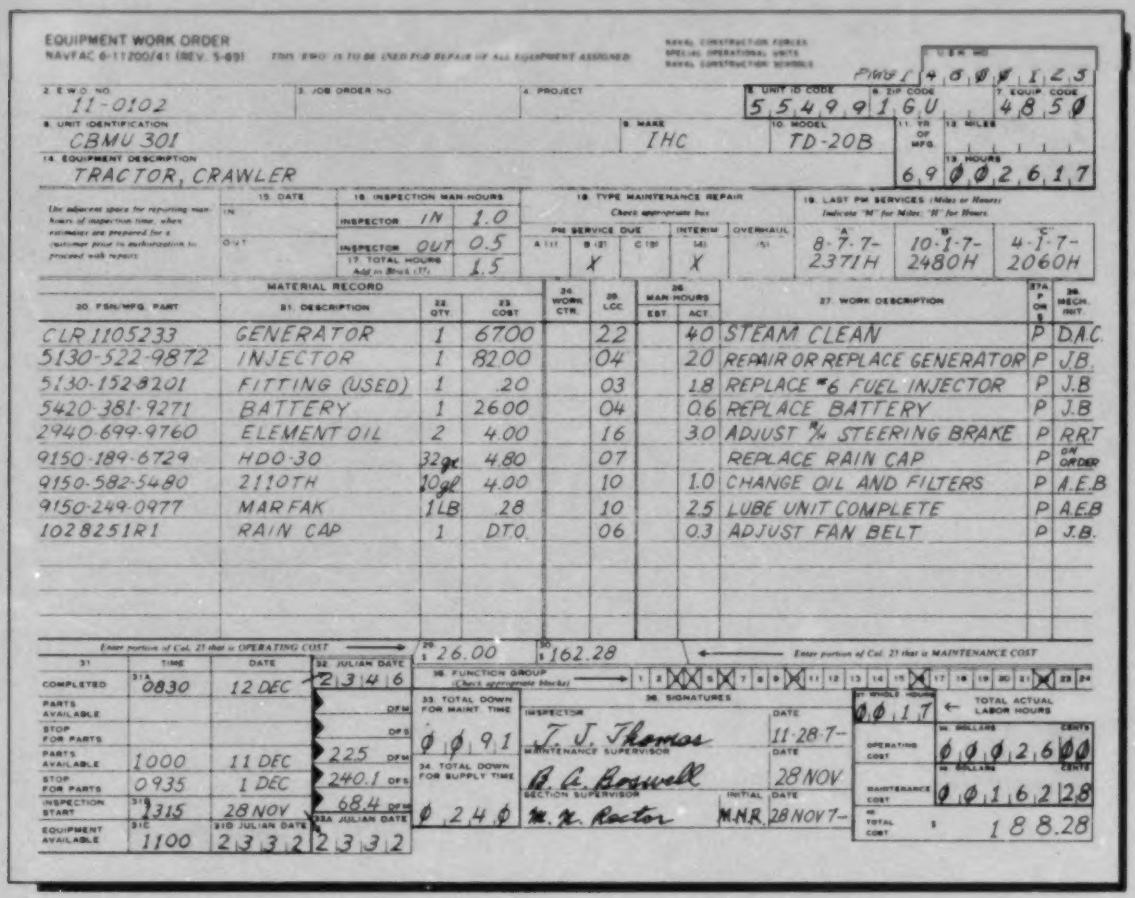
When possible while it is deadlined, this equipment is cycled to prevent deterioration and represerved as necessary.

COST CONTROL

The cost control in a battalion consists basically of accurate reporting of all repair costs, downtime, and other data that relates to the NCB's automotive, construction, weight-handling, and material-handling equipment.

EQUIPMENT WORK ORDER AND CONTINUATION SHEET

The EWO (figure 4-5) and the Continuation Sheet (figure 3-5) are used in the NCF to record costs of repairs, hours required for repairs, and the total time that equipment is



EQUIPMENT WORK ORDER
NAVFAC 6-11200/41 (REV. 5-69)

PWC / 4 0 0 1 2 3

2. E.W.O. NO. 11-0102 | 3. JOB ORDER NO. | 4. PROJECT | 5. UNIT ID CODE 5 5 4 9 9 | 6. ZIP CODE 1 6 U | 7. EQUIP. CODE 4 8 5 0

8. UNIT IDENTIFICATION: CBMU 301 | 9. MAKE: IHC | 10. MODEL: TD-20B | 11. YR OF MFG: 6 9 | 12. MILES | 13. HOURS: 0 0 2 6 1 7

14. EQUIPMENT DESCRIPTION: TRACTOR, CRAWLER

Use adjacent space for reporting man-hours of inspection time, when estimates are prepared for a customer prior to authorization to proceed with repairs.

15. DATE	16. INSPECTION MAN-HOURS	
IN	INSPECTOR IN	1.0
OUT	INSPECTOR OUT	0.5
	17. TOTAL HOURS Add in Block (17)	1.5

18. TYPE MAINTENANCE REPAIR (Check appropriate box)

PM SERVICE DUE A (1)	B (2)	C (3)	INTERIM (4)	OVERHAUL (5)
	X		X	

19. LAST PM SERVICES (Miles or Hours; Indicate "M" for Miles, "H" for Hours)

A	B	C
8-7-7-2371H	10-1-7-2480H	4-1-7-2060H

MATERIAL RECORD

20. FSN/MFG. PART	21. DESCRIPTION	22. QTY.	23. COST	24. WORK CTR.	25. LOC	26. MAN-HOURS EST	26. MAN-HOURS ACT	27. WORK DESCRIPTION	27A. P OR S	28. MECH. INIT.
CLR 1105233	GENERATOR	1	6700		22		4.0	STEAM CLEAN	P	D.A.C.
5130-522-9872	INJECTOR	1	8200		04		2.0	REPAIR OR REPLACE GENERATOR	P	J.B.
5130-1528201	FITTING (USED)	1	.20		03		1.8	REPLACE #6 FUEL INJECTOR	P	J.B.
5420-381-9271	BATTERY	1	2600		04		0.6	REPLACE BATTERY	P	J.B.
2940-699-9760	ELEMENT OIL	2	4.00		16		3.0	ADJUST ¾ STEERING BRAKE	P	RRT
9150-189-6729	HDO-30	32qt	4.80		07			REPLACE RAIN CAP	P	ON ORDER
9150-582-5480	2110TH	10gl	4.00		10		1.0	CHANGE OIL AND FILTERS	P	A.E.B.
9150-249-0977	MARFAK	1LB	.28		10		2.5	LUBE UNIT COMPLETE	P	A.E.B.
1028251R1	RAIN CAP	1	DTO		06		0.3	ADJUST FAN BELT	P	J.B.

Enter portion of Col. 23 that is OPERATING COST → 29 $ 26.00 | 30 $ 162.28 ← Enter portion of Col. 23 that is MAINTENANCE COST

31	TIME	DATE	32. JULIAN DATE
COMPLETED	0830	12 DEC	2 3 4 6
PARTS AVAILABLE			DPM
STOP FOR PARTS			DPS
PARTS AVAILABLE	1000	11 DEC	225 DPM
STOP FOR PARTS	0935	1 DEC	240.1 DPS
INSPECTION START	1315	28 NOV	68.4 DPM
EQUIPMENT AVAILABLE	1100	31C JULIAN DATE 2 3 3 2	33A JULIAN DATE 2 3 3 2

33. TOTAL DOWN FOR MAINT. TIME: 0 0 9.1
34. TOTAL DOWN FOR SUPPLY TIME: 0 2 4 0

35. FUNCTION GROUP (Check appropriate blocks): 1 2 X 5 6 7 8 9 X 11 12 13 14 15 X 17 18 19 20 21 X 23 24

36. SIGNATURES

		DATE
INSPECTOR	J. J. Thomas	11-28-7-
MAINTENANCE SUPERVISOR	R. A. Boswell	28 NOV
SECTION SUPERVISOR	M. K. Rector	INITIAL M.K.R. 28 NOV 7-

37. WHOLE HOURS: 0 0 | HOURS: 1.7 ← TOTAL ACTUAL LABOR HOURS

	38. DOLLARS	CENTS
OPERATING COST	0 0 0 2 6	0 0
MAINTENANCE COST	0 0 1 6	2 8
40. TOTAL COST	$ 188.28	

2.469

Figure 4-5.— Equipment Work Order, NAVFAC Form 6-11200/41.

out of service. The data will help the NCF in budget planning, determining life expectancies of equipment, and predicting future equipment and training requirements. The Naval Facilities Engineering Command Systems Office (FACSO), Port Hueneme, California, also uses the data to compile cost and utilization figures on each piece of USN-numbered equipment. Therefore, the data must be complete, accurate, and neatly recorded in accordance with COMCBPAC/COMCBLANT Instruction 11200 series.

The EWO is the sole authority to perform work on equipment regardless of whether the work is performed in the field or in the shop. An EWO is required each time labor time exceeds 0.3 hour or materials are expended on scheduled PM, interim repairs, modernization or alteration of equipment, or deadline cycling or preservation of equipment. The EWO Log Sheet of figure 4-6 is one means for keeping track of the status of the EWOs.

NOTE: The EWO is expected to be replaced by an Equipment Repair Order (ERO).

REPAIR PARTS

NAVFAC funded initial outfitting repair parts allowances required by the Naval Construction

EWO NUMBER	CODE	USN NUMBER	TYPE EWO				DATE IN	DATE OUT	REMARKS
			INT	A	B	C			
11-0001	2520	25-01286	X				11/2/7-	11/8/7-	
11-0002	0307	97-23465		X			11/2/7-	11/2/7-	
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
11-0102	4850	48-00123	X		X		11/28/7-	12/12/7-	D/L 12/1/7-

EWO NUMBER - Six digit number in numerical sequence. First two digits denote month of year; last four digits assigned jobs in sequence starting with number 1.

CODE - Self-explanatory.

USN NUMBER - Self-explanatory.

TYPE EWO - Type maintenance performed: interim repair, A, B, or C-PM.

DATE IN (SHOP) - Date EWO forwarded to Inspector.

DATE OUT (SHOP) - Date EWO returned, work completed.

REMARKS - Date deadlined etc.

2.470

Figure 4-6.—Equipment Work Order Log Sheet.

Force (NCF) for support of its assigned equipment are listed in Consolidated Seabee Allowance Lists (COSALs). The COSAL establishes the support for assigned Organic and Augment equipment based on USN numbered listings. COSALs are published under the authority contained in the NAVFAC/NAVSUP Program support agreement by Navy Ships Parts Control Center, Mechanicsburg (SPCC). COSALs are both technical and supply documents. They are technical documents in that equipment nomenclature, operating charteristics, technical manuals, etc, are described in Allowance Parts Lists. They are supply documents in that they list all parts by manufacturer's code and part number, national stock number, unit of issue, and price and quantity authorized by NAVFAC maintenance policy. Repair parts allowances are designed to provide a 90% effectiveness for 1,800 construction hours or 90 days support. This 90-day period is defined as a 3-month utilization period for vehicles or equipment in new or like new condition. Selection of parts included in the COSAL are made after identification, usage and insurance items are coded by maintenance capability in accordance with NAVFAC lead Allowance Parts Lists.

Maintenance codes are used to control the allowed item range for each of the various organizational maintenance capabilities. The definition and application of maintenance codes are contained in Appendix C of the COSAL introduction. There are two basic categories of repair parts; parts peculiar—NAVSUP modifier code 98 and parts common—NAVSUP modifier code 97. These are published in two separate COSALs. Parts peculiar are applicable only to specific makes or models of equipments. Parts common are general repair type items, (Appendix G of the COSAL introduction) and are not referenced to any specific equipment. Military and commercial operators manuals, parts manuals and maintenance manuals are listed in the parts peculiar COSAL. A descriptive account showing the method of entry and how to use the COSAL is contained in Appendix F of the COSAL instruction.

Supply Aids

In order to assist personnel in the repair parts program, the following supply aids have been developed and are distributed with each COSAL:

NAVSUP1114(fig. 4-7) — Printed stock record cards.

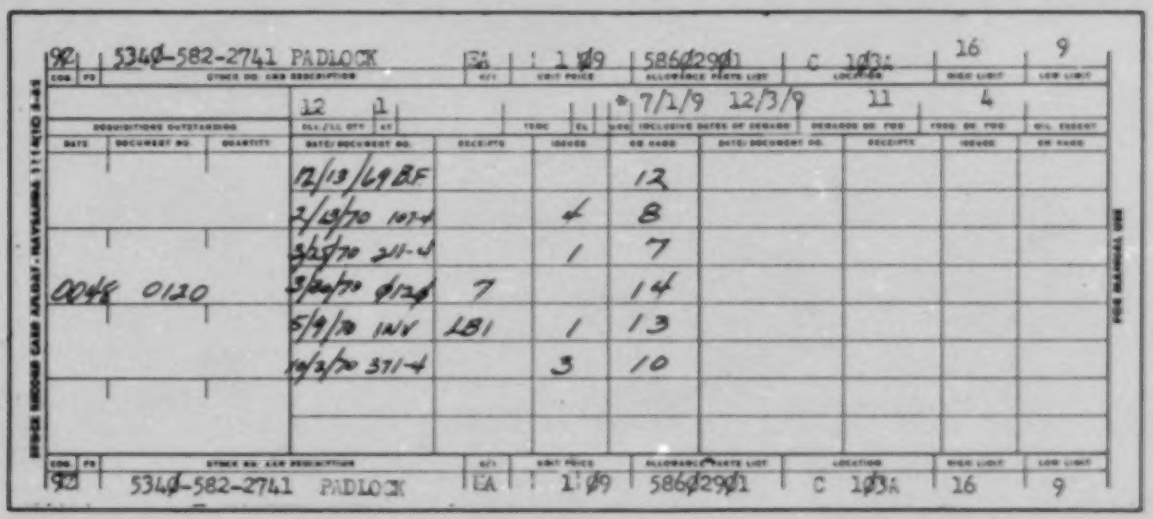
Add Item Listing — Repair parts provided by an Naval Construction Battalion Center (NCBC) to support new equipment not previously supported.

Delete Item Listing — Repair parts provided by a previous COSAL that are no longer required.

DD 1348-1 (fig. 4-8) — Single Line Item Release/Receipt Document.

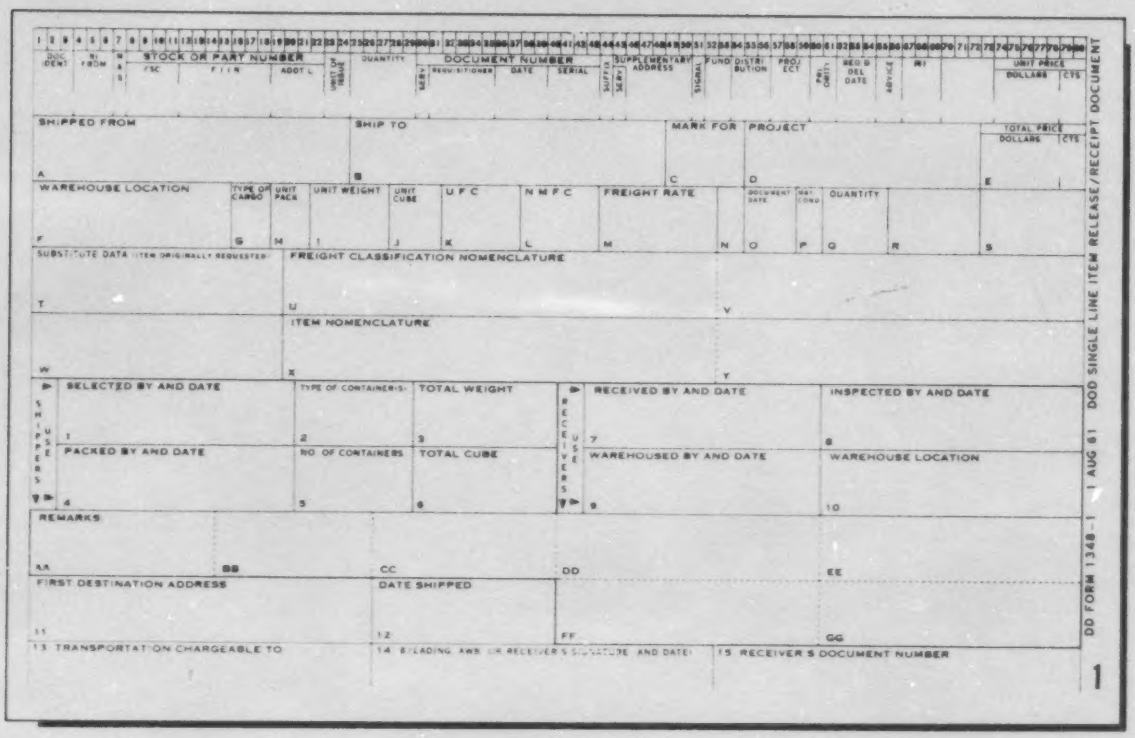
Transfer Item Listing — A list showing previous COSAL items which must be transferred to other locations due to equipment transfer.

Summary Item List — A composite list of all items required by the old COSAL.



66.19

Figure 4-7.—Stock Record Card Afloat, NAVSUP Form 1114.



2.471

Figure 4-8.—Single Line Item Release/Receipt Document, DD Form 1348-1.

Stock Number Changes—

Two listings (old-to-new National Stock Number (NSN) and new-to-old (NSN) which show changes in the stock number listed in the old COSAL and updated by the new COSAL.

Prepackaged Library

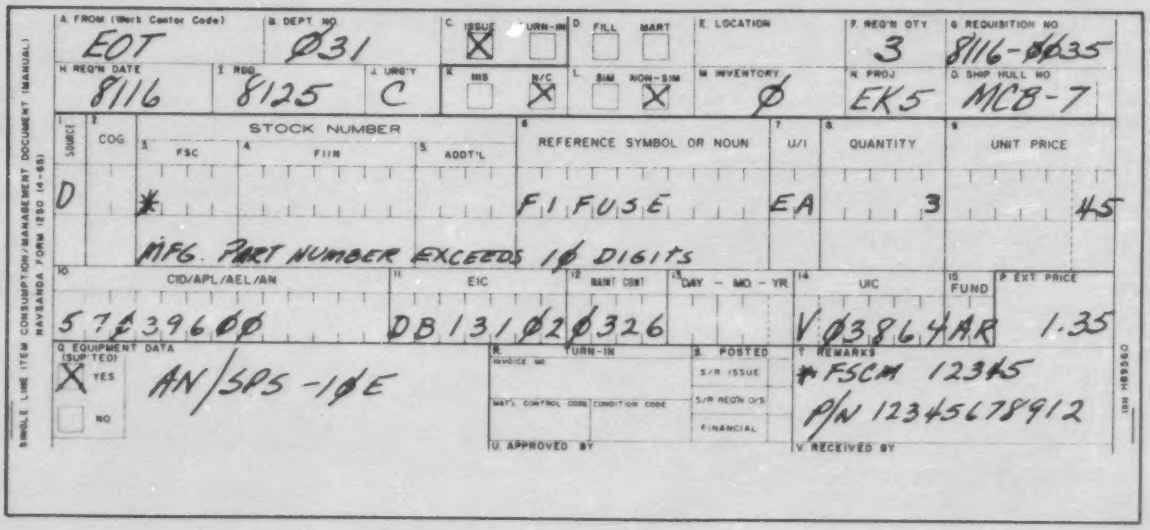
A prepackaged library contains history jackets for all assigned equipment, technical manuals, manufacturers' parts manuals, shop manuals, and operators' manuals. In many cases the operators' manual is contained in the shop manual.

Shop manuals should be centrally located and accounted for directly since they seem to find their way into personal lockers or just disappear.

Procedures for Requisitioning Repair Parts

The NAVSUP Form 1250 shown in figure 4-9, is used as authorization for drawing or ordering repair parts. Preparation of the 1250 must be in accordance with NAVSUP P-485 Section 6207 and is the responsibility of the appropriate shop supervisor.

When ordering repair parts that are in stock, indicate the required part by its nomenclature as given in the applicable maintenance manual and by other information required by the local command. After being authorized by the shop supervisor or higher authority, the NAVSUP 1250 and the EWO are presented to the Storekeeper at the repair parts section. The Storekeeper



17.84

Figure 4-9.—Single Line Item Consumption/Management Document (Manual), NAVSUP Form 1250.

determines and records all applicable information and takes other appropriate action as directed by the supply officer. After the required part is obtained, the yellow copy of the 1250 is attached to the EWO.

When ordering repair parts not in stock, follow the same procedure outlined above except that, when it is determined that the required part is not available immediately, the NAVSUP 1250 is annotated (marked) with data concerning like items on order but not received and also marked NIS (Not In Stock) or NC (Not Carried) and returned to the mechanic. The maintenance supervisor or higher authority assigns a priority and authorizes the part to be ordered. The cost control clerk assigns a department order number for each part ordered, starting with number 0001. Pull the yellow copy and forward the other copies of the 1250 to supply. Supply will complete the ordering action and return the red copy of the 1250 with a requisition number to the cost control clerk. If the red copy is not received within seven days, request Supply to furnish you with a status of your order.

The following information is provided as a guide in determining the number of days it usually takes to receive repair parts, or a status report on the requisition for repair parts.

REQUISITION PRIORITY	CONUS TIME (DAYS)	OVERSEAS TIME (DAYS)
2	5	7
5	8	15
12	20	45

To maintain an accountability and status of your requisitioned repair parts, the following procedure is given:

1. For Parts Pending Action: The Stock Control Clerk maintains one repair parts summary sheet (fig. 4-10) for each item of equipment assigned. This sheet is filed by PM group. The Stock Control Clerk enters the data from the yellow copy of the 1250 on the appropriate repair parts summary sheet, then files the yellow EWO and yellow 1250 with the sheet. Upon receipt of the red 1250, he enters the requisition number on the sheet and files the red 1250 in place of the yellow 1250.

2. For Deadline Parts Action: The procedure outlined above is followed, except that the repair parts summary sheet is filed with the complete EWO in the deadline file.

3. Upon Receipt of Parts: On receiving an ordered repair part, Supply will forward a copy of the DD Form 1348-1 (figure 4-8) to the Cost Control Clerk. The Cost Control Clerk tags the repair part with the correct USN number,

CODE 4850 USN 48-00123

DATE	DEPT. NO.	PRI	REQ. NO.	NOMENCLATURE	FOLLOW-UP			REC'D
1/18/7-	0009	12	2021-2211	GASKET SET	1/31			2/28
8/7/7-	0161	05	2230-2713	INJECTOR	8/28	9/15	10/2	10/11
12/12/7-	0218	05		RAINCAP				

CODE - Self-explanatory.

USN - Self-explanatory.

DATE - When the 1250 was submitted to Supply for ordering.

DEPT. NO. - Four digit number in numerical sequence starting with number 0001 for each 1250 you submitted to Supply.

PRI - See COMCBPAC or COMCBLANT 4614.1 Series Instruction.

REQ. NO. - Supply's voucher number found in Block G of the 1250. Enter after red 1250 is returned from Supply.

NOMENCLATURE - Self-explanatory.

FOLLOW-UP - When did you request status from Supply.

REC'D - Self-explanatory.

2.472

Figure 4-10.—Repair Parts Summary Sheet.

PM group and the red 1250 copy. He ensures that the DTO Log and the Summary Sheet show the date the part was received. The part is then stored in the DTO bin and the 1348-1 is filed with the appropriate Summary Sheet. Each time an EWO is issued, the Cost Control Clerk checks the Repair Parts Summary Sheets to determine whether or not parts are stored in the DTO bin for the equipment concerned. If they are stored, he alerts the shop supervisor by attaching the 1348-1 to the EWO. The Shop Supervisor will ensure that the parts are either used or returned to the Unit Supply. If the received part is for a deadlined piece of equipment, the Maintenance Supervisor is notified to determine if enough parts are available to restart work on the equipment.

BATTALION EQUIPMENT EVALUATION PROGRAM

The reliability of equipment is one of the main factors in the ability of an NMCB to perform its assigned mission. The Battalion Equipment Evaluation Program is a vital link in maintaining the degree of equipment readiness required of a battalion. Before you take a look at this program from the maintenance viewpoint, you should familiarize yourself with current COMCBPAC and COMCBLANT Instructions, 11200.19 Series. These instructions are established as uniform procedures which occur during a battalion's on-site relief and equipment turnover.

Responsibilities of the Relieving Battalion

Prior to arriving on site, the incoming battalion is responsible for the following:

1. Notify COMCBPAC or COMCBLANT, Commander, 31st NCR, and the battalion being relieved at least 30 days prior to the desired BEEP commencement date.
2. Ensure that personnel required for the BEEP are assigned to the advance party.
3. Ensure that required documents and supplies accompany the advance party.

Responsibilities of the Battalion Being Relieved

Prior to, and during the BEEP, the battalion being relieved is responsible for the following:

1. Coordinate the BEEP commencement date with the incoming battalion.
2. Assign counterparts to personnel arriving with the incoming battalion, and ensure that these men remain on site until completion of the BEEP.
3. Make available all necessary tools and shop equipment with which to accomplish the evaluation and repair of the equipment.
4. Clean and make available all equipment for evaluation and repair.
5. Coordinate the scheduling of equipment for inspection with the incoming battalion.

NOTE: The recommended procedure is to schedule the equipment by PM Group, using the appropriate number of PM Groups to enable the BEEP to be completed within 10 working days.

6. Ensure that an EWO with a copy of the Equipment Evaluation Inspection Guide (figure 4-11), along with a copy of the Attachment Evaluation Inspection Guide (figure 4-12), when appropriate, is prepared for each item of equipment.

Joint Responsibilities

The following tasks are accomplished jointly by the battalions during the BEEP.

1. An inspection of all maintenance records, noting accuracy and deficiencies and updating as required.
2. A review and accountability of all maintenance correspondence which is pending final action.
3. An inventory and inspection of all permanent Alfa Company shop equipment noting condition and deficiencies. Submit a list to the COMCBLANT or Commander, 31st NCR representative, noting the condition and deficiencies.
4. A preventive maintenance inspection of each nonpreserved item of USN-numbered equipment assigned, using the Equipment Evaluation Inspection Guide. Accomplish all repairs possible dependent upon the work force, space, and repair parts available as determined jointly by both maintenance supervisors.

NOTE: All nonpreserved equipment is inspected to at least the "B" PM level. Engine oil and oil filters are

changed on all equipment that has not had a "B" or "C" PM within the previous 30 calendar days.

5. A preventive maintenance inspection of all equipment attachments, using an Attachment Evaluation Inspection Guide. Accomplish all repairs possible dependent upon the work force, space, and repair parts available as determined jointly by both maintenance supervisors.

6. A visual inspection of each preserved item of assigned USN-numbered equipment, using an Equipment Evaluation Inspection Guide. The equipment is not depreserved for testing unless visual inspection shows major discrepancies.

The Equipment Condition Codes as defined below are used in completing the parts of figures 4-11 and 4-12 that describe the overall condition of the equipment being BEEPed.

ALPHABETICAL CODING

N - New, unused.

E - Used, but reconditioned (overhauled); Not used since overhaul.

O - Used; fully operational, without repairs.

R - Deadlined; repairs required before this item can perform its intended mission.

X - No further value for use as orginally intended.

NUMERICAL CODING

1 - Excellent Condition (repairs would cost no more than 10% of acquisition cost to upgrade condition to E-1).

2 - Good Condition. Does not qualify for excellent; slightly shop worn, but with considerable use left before any important repairs would be required. (Repairs would cost from 11% to 25% of acquisition cost to upgrade to E-1.)

3 - Fair Condition. Worn, rusted or deteriorated to the extent where some parts or portions should be replaced. (Repairs would cost from 26% to 40% to upgrade to E-1.)

4 - Poor Condition. Badly worn, rusted, deteriorated and would still be in doubtful state of dependability and uneconomical in use, if repaired at location. (Repairs would cost from 41% to 65% of acquisition cost to upgrade to E-1.)

NOTE: Repair costs by percentage of acquisition as set forth in numerical coding will only pertain to deadlined equipment only.

Repair Parts (BEEP)

The repair parts portion of the BEEP will be accomplished in accordance with COMCBPAC/COMCBLANT Instruction 4040.1 series.

55B

			DATE	
CODE	USN NO.	MILEAGE	HOURS	ENGINE SERIAL NO.
PRESTART INSPECTION: INSPECTORS	INITIALS	NMCB	INITIALS	NMCB
COOLING SYSTEM	LEVEL	LEAKS	CONDITION	
LUBRICATION SYSTEM	LEVEL	LEAKS	CONDITION	
CHARGING SYSTEM	BATTERY LEVEL	BELTS	CABLES	CONNECTIONS
LIGHTING SYSTEM	HEADLIGHTS	TAIL LIGHTS	BLACK OUT	INSTRUMENTS
	CLEARANCE	REFLECTORS	REMARKS	
FUEL SYSTEM	LEVEL	LEAKS	CONDITION	
TIRES	SIZE	TYPE TREAD	CONDITION	INFLATION
	MOUNTED SPARE SIZE		CONDITION	INFLATION
TRACKS	RAILS	PINS	SHOES	SPROCKETS
	IDLERS	REMARKS		
MISCELLANEOUS	AUTO TRANS FLUID		MIRRORS	LUG NUTS
	CONTROLS	CABLES	DOORS	GLASS
	UPHOLSTERY		BODY CONDITION	
REMARKS				
ENGINE RUNNING: INSPECTORS	INITIALS	NMCB	INITIALS	NMCB
ACCESSORIES	INSTRUMENTS	WARNING DEVICES		HORN
	W/S WIPERS	BRAKES	CLUTCH	HAND BRAKE
LEAKS	ENGINE	TRANSMISSION		TRANSFER CASE
	DIFFERENTIALS	BRAKES	STEERING	WINCH
ENGINE PERFORMANCE	STARTING	IDLING	FULL LOAD	
	PARTIAL LOAD		REMARKS	
VEHICLE PERFORMANCE	STEERING	BRAKES	CLUTCH	TRANSMISSION
	DIFFERENTIALS	TRANSFER CASE	PTO	WINCH
	HYD SYSTEM	DRIVE SHAFTS	UNUSUAL NOISE/MOTION	
REMARKS				

Figure 4-11.— Equipment Evaluation Inspection Guide.

2.473

INVENTORY

INSPECTORS	INITIALS	NMCB	INITIALS	NMCB
COLLATERAL EQUIPAGE INVENTORY	DISCREPANCIES SHORTAGES			
OPERATIONS SUPERVISORS	INITIALS	NMCB	RECOMMENDED CONDITION CODE	
	INITIALS	NMCB	RECOMMENDED CONDITION CODE	
REMARKS				

SHOP INSPECTION AND REPAIR

INSPECTORS	INITIALS	NMCB	INITIALS	NMCB
MOUNTING BOLTS	ENGINE	TRANSMISSION	AXLES	TRANSFER CASE
	SPRINGS	BODY	CAB	FENDERS
	FUEL TANKS	REMARKS		
MISCELLANEOUS	EXHAUST SYSTEM	SPRINGS	SHOCKS	TIE RODS
	DRAG LINK	IDLER ARM	CONTROL LINKAGE	
AIR INTAKE SYSTEM	CLEANER COND	PIPING CONNECT	TURBOCHARGER, BLOWER	
FRONT WHEELS	BRAKE LINING	BEARING ASSEMBLYS		SEALS
	BOOTS	DRUMS	CYLINDERS	BACKING PLATE
	SHOE MOUNT	ADJUST MECH	REMARKS	
REAR WHEELS	BRAKE LINING	BEARING ASSEMBLYS		SEALS
	BOOTS	DRUMS	CYLINDERS	BACKING PLATE
	SHOE MOUNT	ADJUST MECH	REMARKS	
SHOP SUPERVISOR	MAKE MINOR REPAIRS ORDER PARTS (Initials)			
	FINAL INSPECTION (Initials)			

OVERALL CONDITION

	N - NEW		1 - EXCELLENT
	E - USED-RECONDITION		2 - GOOD
	O - USED-USABLE WITHOUT REPAIRS		3 - FAIR
	R - USED-REPAIRS REQUIRED		4 - POOR
	X - NO FURTHER VALUE FOR USE AS ORIGINALLY INTENDED		

ABOVE CONDITION AGREED TO BY MAINTENANCE SUPERVISORS FROM BOTH BATTALIONS

NMCB (SIGNATURE)	NMCB (SIGNATURE)

2.473

Figure 4-11.—Equipment Evaluation Inspection Guide—continued.

				DATE
I. D. NUMBER	DESCRIPTION		LOCATION	
ASSIGNED TO CODE	USN NO.	MOUNTED/UNMOUNTED		NAVFAC 6-11200/45
INSPECTORS	INITIALS	NMCB	INITIALS	NMCB
PRESTART INSPECTION	FRAME	MOUNTINGS	MOUNTING HARDWARE	
	CONTROLS	CABLES/SHEAVES		BUSHINGS/BEARINGS
	HOSES	HYD SYSTEM	CUTTING EDGE/TEETH	
REMARKS				
INSPECTORS	INITIALS	NMCB	INITIALS	NMCB
OPERATIONAL INSPECTION	PARTIAL LOAD		FULL LOAD	
	REMARKS			
OPERATIONS SUPERVISORS	INITIALS	NMCB	RECOMMENDED CONDITION CODE	
	INITIALS	NMCB	RECOMMENDED CONDITION CODE	
REMARKS				
SHOP SUPERVISOR	MAKE MINOR REPAIRS /ORDER PARTS (Initials)			
	FINAL INSPECTION (Initials)			
OVERALL CONDITION				
	N - NEW		1 - EXCELLENT	
	E - USED-RECONDITION		2 - GOOD	
	O - USED-USABLE WITHOUT REPAIRS		3 - FAIR	
	R - USED-REPAIRS REQUIRED		4 - POOR	
	X - NO FURTHER VALUE FOR USE AS ORIGINALLY INTENDED			
ABOVE CONDITION AGREED TO BY MAINTENANCE SUPERVISORS FROM BOTH BATTALIONS				
NMCB (SIGNATURE)		NMCB (SIGNATURE)		

2.474

Figure 4-12.—Attachment Evaluation Inspection Guide.

CHAPTER 5

ENGINE OVERHAUL

The engine of any piece of equipment is taken for granted as long as it runs smoothly and efficiently. But all engines lose power sooner or later from normal wear. When this happens you must be able to determine the cause and know what is needed to correct the trouble.

Generally speaking, it is not your job to perform engine repairs; but it IS your job to see that these repairs are performed correctly by your men. You may, of course, frequently have to give them assistance and instruction in these tasks.

Since the SEABEES use many models of internal combustion engines, it is impossible to specify the detailed overhaul procedures for all the engines. However, here are several basic principles which apply to all engine overhauls:

1. Consult the detailed repair procedures given in manufacturers' instruction and maintenance manuals. Study the appropriate manuals and pamphlets before attempting any repair work. Pay particular attention to tolerances, limits, and adjustments.
2. Observe the highest degree of cleanliness in handling engine parts during overhaul.
3. Before starting repair work, be sure all required tools and replacements for known defective parts are available.
4. Keep detailed records of repairs, such as the measurements of parts, hours of use, and new parts installed. An analysis of these records will indicate the hours of operation that may be expected from the various engine parts, and help you in determining when a part should be renewed in order to avoid a failure.

Since maintenance cards, manufacturers' technical manuals, and various instructions contain repair procedures in detail, this chapter will be limited to general information on some of the troubles encountered during overhaul, their causes, and methods of repair.

HORSEPOWER AND HORSEPOWER RATINGS

It is your business to know a great deal about horsepower and horsepower ratings. In preparing for your rate as a CM3 or CM2, you learned that horsepower is a unit for measuring work per unit of time, and that one horsepower is equivalent to 33,000 foot-pounds of work per minute. You also learned how horsepower is determined—either mechanically measured, or mathematically computed.

In your new duties, you will be consulting maintenance manuals for engine performance data and specifications. Here you will come across additional horsepower designations, and many different horsepower ratings used by manufacturers in describing their equipment. The methods used in measuring power, and the purpose for which it is intended, account for the variety of horsepower and horsepower ratings.

INDICATED HORSEPOWER

INDICATED HORSEPOWER is the theoretical power that an engine would deliver if all frictional losses were eliminated. It is used mainly by experimental engineers in designing new and more efficient engines. Indicated horsepower may be computed from the following formula:

$$\text{Indicated HP} = \frac{\text{PLANK}}{33{,}000}$$

Where

P = Mean effective pressure in pounds per square inch. This is the average pressure on the piston during the power stroke minus the average pressure during the other three strokes.
L = Length of stroke in feet
A = Area of piston head in square inches

N = Working strokes per minute
K = Number of cylinders in the engine
33,000 = The equivalent of one horsepower in foot-pounds per minute

Of all the factors given in this formula, only cylinder pressure (P) and engine rpm (N) can be changed during the normal operation of the engine. The remaining factors are constant as you can see by studying the formula.

BRAKE HORSEPOWER

BRAKE HORSEPOWER is the actual amount of power that an engine can deliver at a certain speed with a wide open throttle. The term, brake horsepower, is derived from the braking device (usually a dynamometer) which is applied to measure the horsepower an engine develops. The dynamometer consists of a resistance creating device, such as an electric armature revolving in a magnetized field. A paddle wheel revolving in a fluid may also be used to absorb the energy.

An ENGINE DYNAMOMETER may be used to test an engine that has been removed from the vehicle it drives. If the engine does not develop the manufacturer's recommended horsepower and torque at specific rpms, you know the engine must be tuned up or repaired.

The CHASSIS DYNAMOMETER can give a quick report on engine conditions by measuring output at various speeds and loads. It is useful in shop testing and adjusting automatic transmissions.

On the chassis dynamometer, figure 5-1, the driving wheels of the vehicle are placed on rollers. The engine drives the wheels and the wheels drive the rollers. By loading the rollers varying amounts and by running the engine at different rpms, you can simulate nearly all normal driving conditions. The tests and checks can be made without the interference of body noises, such as you would have when checking the vehicle on the road.

FRICTION HORSEPOWER

FRICTION HORSEPOWER is the difference between indicated horsepower and brake horsepower. Actually, it is the power required to overcome friction within the engine, such as

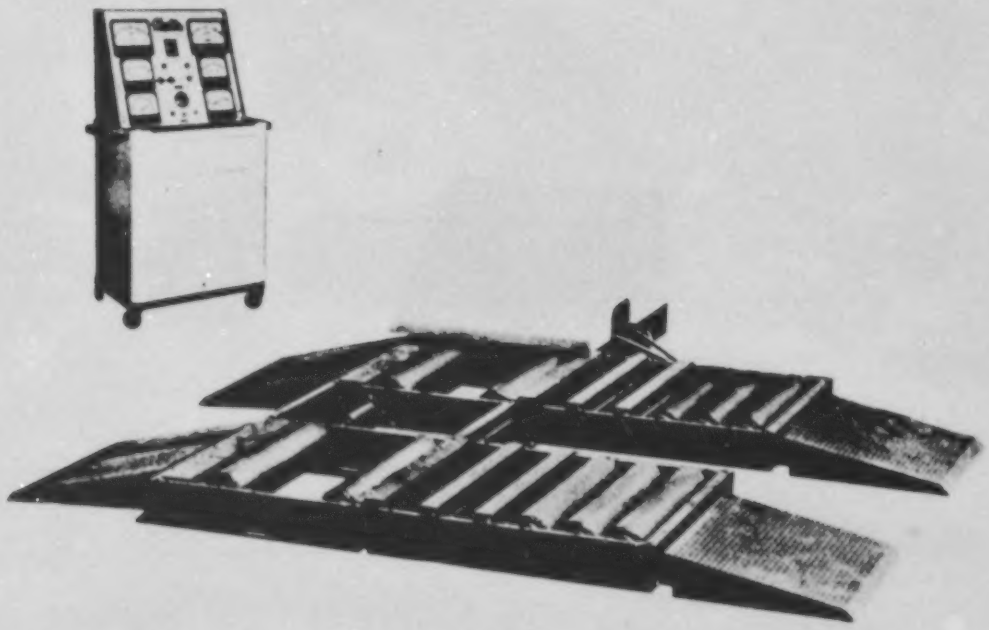


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Figure 5-1.—Chassis dynamometer.

friction between engine parts, resistance in driving accessories, and, among other things, loss due to pumping action of the pistons. The latter may be compared to the effort required to raise the handle of a hand-operated tire pump. It may be difficult to properly define friction horsepower, but you may be sure that with proper maintenance, it can be reduced to improve the mechanical efficiency of the engine.

DRAWBAR AND BELT HORSEPOWER

Two kinds of horsepower commonly used by manufacturers in rating the power of contruction vehicles are belt horsepower and drawbar horsepower.

BELT HORSEPOWER is equivalent to the rated engine power, except in cases where the belt pulley is driven through a gear train. In this case, there is a slight loss of power caused by gear friction. Also, while there may be some belt-pulley slippage, it is considered negligible in arriving at the belt horsepower rating.

DRAWBAR HORSEPOWER is the power that can be exerted in pulling a load. Specifications of the Caterpillar D-8 H series with a D-342 engine, for example, rate the drawbar horsepower at 180.

TAXABLE HORSEPOWER

The National Automotive Chamber of Commerce has developed a simplified method of determining taxable horsepower based on the bore of the engine and the number of cylinders. This specification is listed in most manufacturers' manuals, but it does not truly represent the actual horsepower of modern high speed, high compression engines. It is used for licensing purposes only in some states.

GRAPHS AND DIAGRAMS

Graphs and diagrams are abbreviated methods of recording operation and maintenance data.

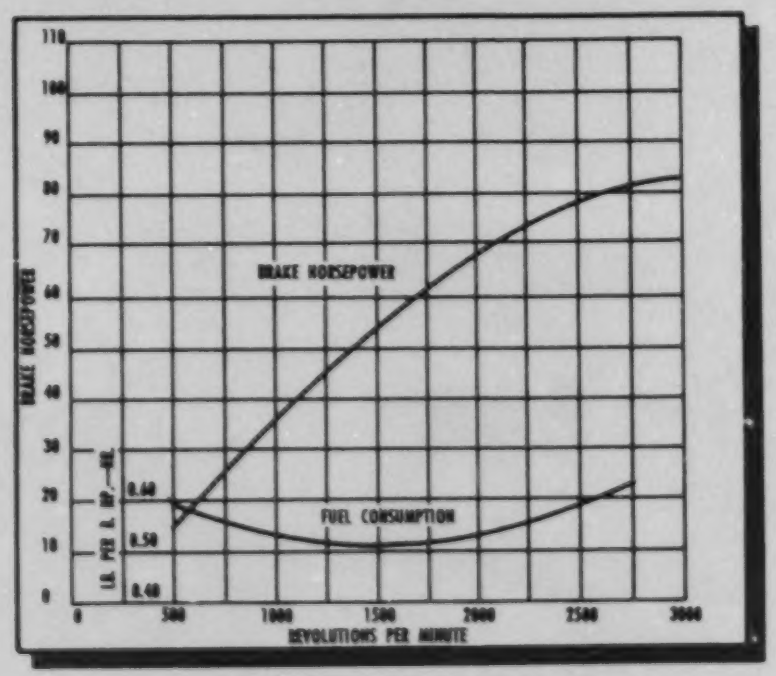

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Figure 5-2.—Performance curves of a typical 6-cylinder gasoline engine.

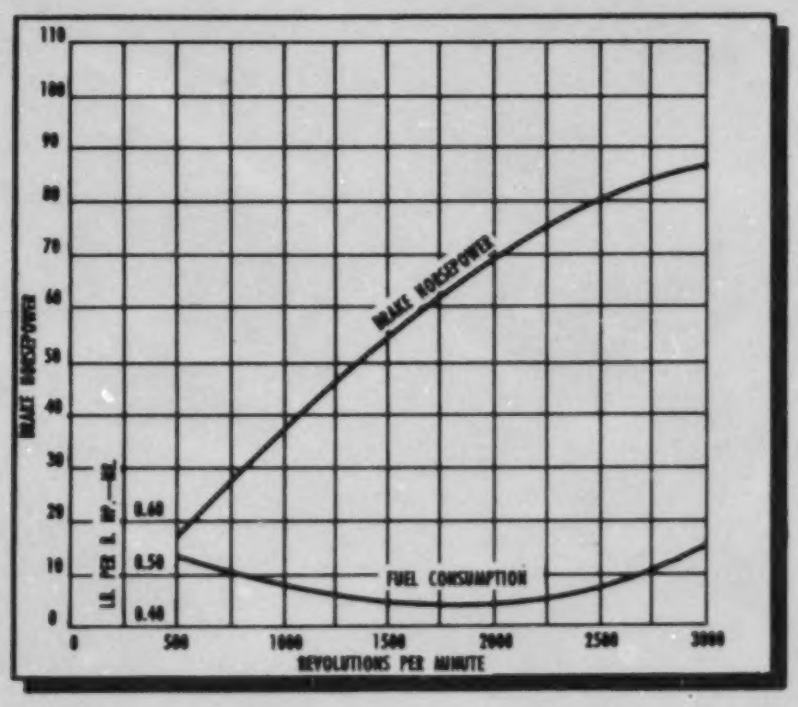

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Figure 5-3.— Performance curves for a typical 6-cylinder diesel engine.

Manufacturers' operation and maintenance manuals often contain graphs and diagrams. The technical bulletins, prepared chiefly for tuneup mechanics, may use a particular graph or diagram to eliminate pages of written description that otherwise would be necessary.

PERFORMANCE CURVES

Figure 5-2 and 5-3 are examples of graphs that describe engine performance in terms of brake horsepower and fuel consumption. Dynamometer tests provide the data used in plotting the performance curves for each engine. Figure 5-4 is another example of a graph. It shows that the amount of torque an engine produces varies with its speed. The relationship between torque and horsepower is shown in figure 5-5. You find that horsepower is related to both torque and speed. When both are increasing, as they do between 1,200 and 1,600 rpm, then horsepower goes up sharply. As torque reaches maximum and begins to taper off, horsepower continues to rise to maximum. The horsepower starts to decline beyond rated speed where torque falls off sharply.

TIMING DIAGRAMS

Engine timing, as described in Construction Mechanic 3 & 2, is largely a matter of opening and closing valves or ports, and of adjusting ignition or fuel injection, so that these events occur at the proper time in the cycle of engine operation. Timing diagrams picture these events in relation to each other and in relation to top dead center (TDC) and bottom dead center (BDC). They are useful to the CM for quick and easy reference. However, before timing diagrams can be very useful, you will need to recall a few facts about engine cycles.

The 4-stroke cycle engine makes 2 complete crankshaft revolutions in 1 cycle (intake, compression, power, and exhaust). The 2-stroke cycle engine completes a cycle with just 1 crankshaft revolution. With diesel engine cycles

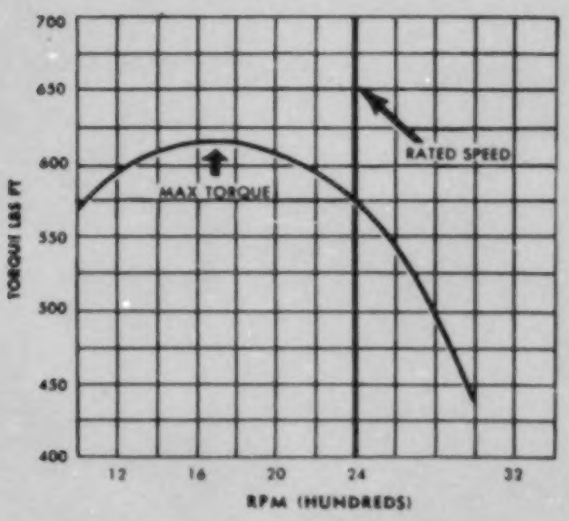

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Figure 5-4.—Graph showing relationship between torque and speed.

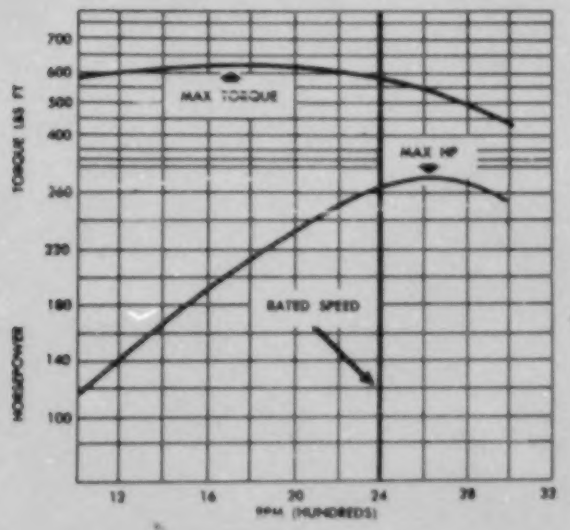

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Figure 5-5.—Relationship between torque and horsepower.

(2- and 4-stroke), the event of fuel injection will be shown on the timing diagram instead of spark ignition which is common to gasoline engine operating cycles.

Four-Stroke Cycle Engine Timing

Figure 5-6 illustrates a typical timing diagram for a 4-stroke cycle diesel engine. The actual length of the strokes illustrated and the beginning of fuel injection will vary a few degrees in either direction depending on a specific manufacturer's recommendations. Follow the events in this cycle by tracing the circular pattern around 2 complete revolutions in a clockwise direction.

Start TDC with the beginning of the POWER STROKE. Compression is at its peak, fuel injection has been completed, and combustion is taking place. Power is delivered to the crankshaft as the piston is driven downward by the expanding gases in the cylinder. Power delivery ends when the exhaust valve opens.

After the exhaust valve opens, the piston continues downward to BDC and then is driven upward in the EXHAUST STROKE. The exhaust gases are pushed out of the cylinder as the piston rises to TDC, and the exhaust valve closes a few degrees after TDC to ensure proper scavenging. The crankshaft has made a complete revolution during the power and exhaust strokes.

The intake valve opens a few degrees before TDC—to aid in scavenging the cylinder—near the end of the upward exhaust stroke. As the crankshaft continues to rotate past TDC, the INTAKE STROKE begins. The intake stroke continues for the whole downward stroke and part of the next up stroke to take advantage of the inertia of the incoming charge of fresh air.

The rest of the upward stroke is the COMPRESSION STROKE, which begins at the instant of intake valve closing and ends at TDC. FUEL INJECTION may begin as much as 40 degrees before TDC, and continue to TDC, thus completing the power cycle and second complete revolution of the engine.

By substituting the event of IGNITION for fuel injection, figure 5-6 could easily represent a timing diagram for a typical gasoline engine.

For additional information on diesel fuel injection system tests that can be made both in the shop and in the field, refer to the manufacturer's service manual.

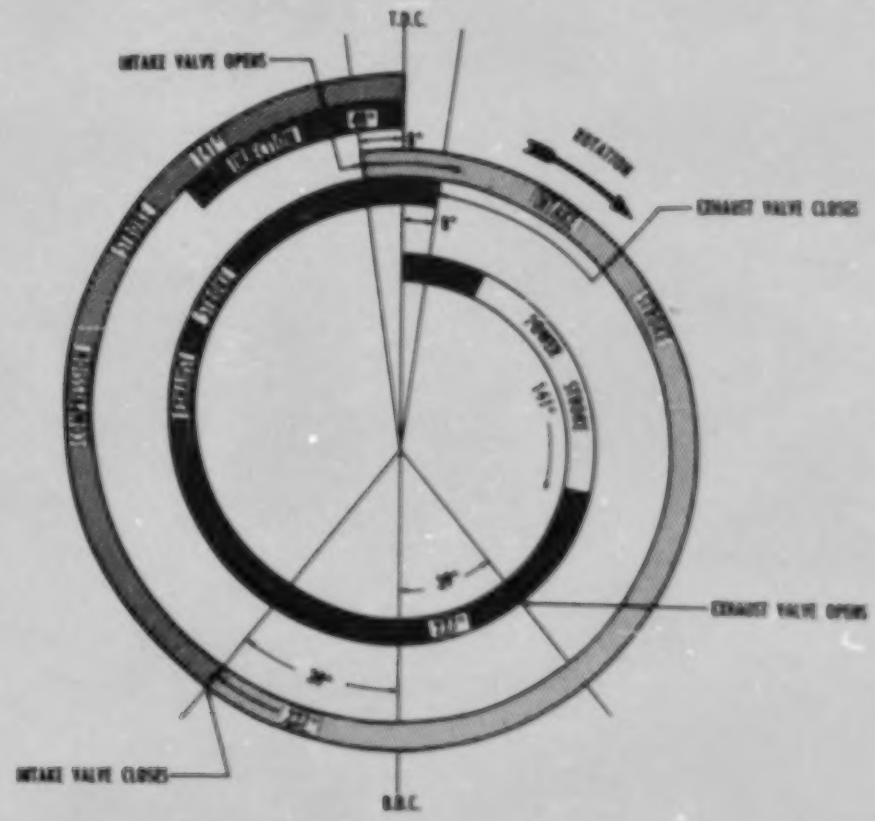

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Figure 5-6.—Typical timing diagram of a 4-stroke cycle diesel engine.

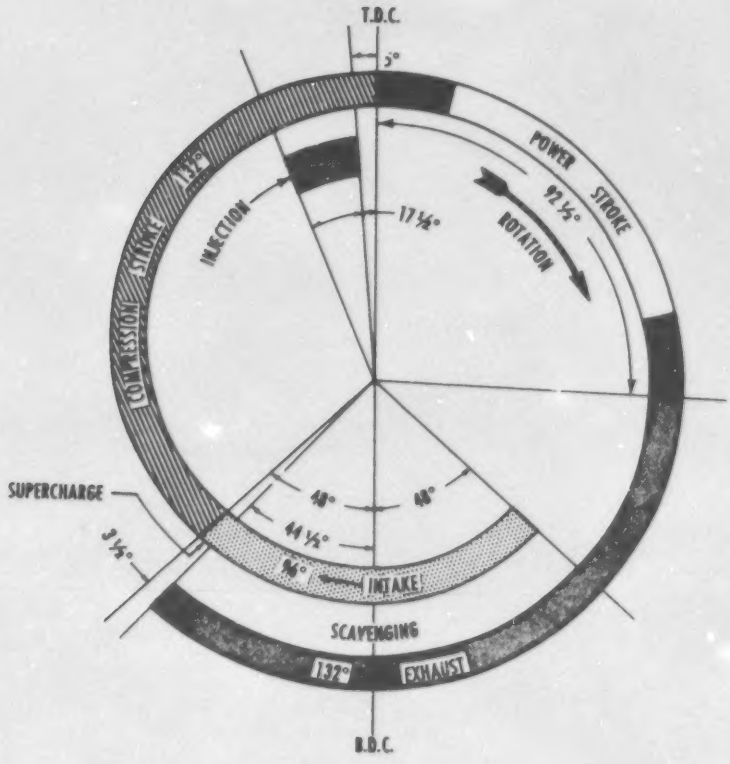
Two-Stroke Cycle Engine Timing

Figure 5-7 illustrates a timing diagram of a 2-stroke cycle diesel engine. This engine is typical of the General Motors series which uses a blower to send fresh air into the cylinder and to clear out the exhaust gases. The movement of the piston itself does practically none of the work of intake and exhaust as it does in a 4-stroke cycle engine. This fact is important to the mechanic in detecting 2-stroke cycle diesel engine power losses.

Beginning at TDC (fig. 5-7), the fuel has been injected and combustion is taking place. The piston is driven down and power is delivered to the crankshaft until the piston is just a little more than halfway down. The exhaust valves (2 in each cylinder) open 92-1/2 degrees after TDC. The exhaust gases blow out through the manifold and the cylinder pressure drops off rapidly.

At 132 degrees after TDC (48 degrees before BDC), the intake ports are uncovered by the downward movement of the piston. Scavenging air under blower pressure swirls upward through the cylinder and clears the cylinder of exhaust gases. This flow of cool air also helps to cool the cylinder and the exhaust valves. Scavenging continues until the piston reaches 44-1/2 degrees after BDC. At this point, the exhaust valves are closed. The blower continues to send fresh air into the cylinder for just a short time (only 3-1/2 degrees of rotation), but it is sufficient to give a slight supercharging effect.

The intake ports are closed at 48 degrees after BDC and compression takes place during



2.24

Figure 5-7.— Timing diagram of a 2-stroke cycle diesel engine.

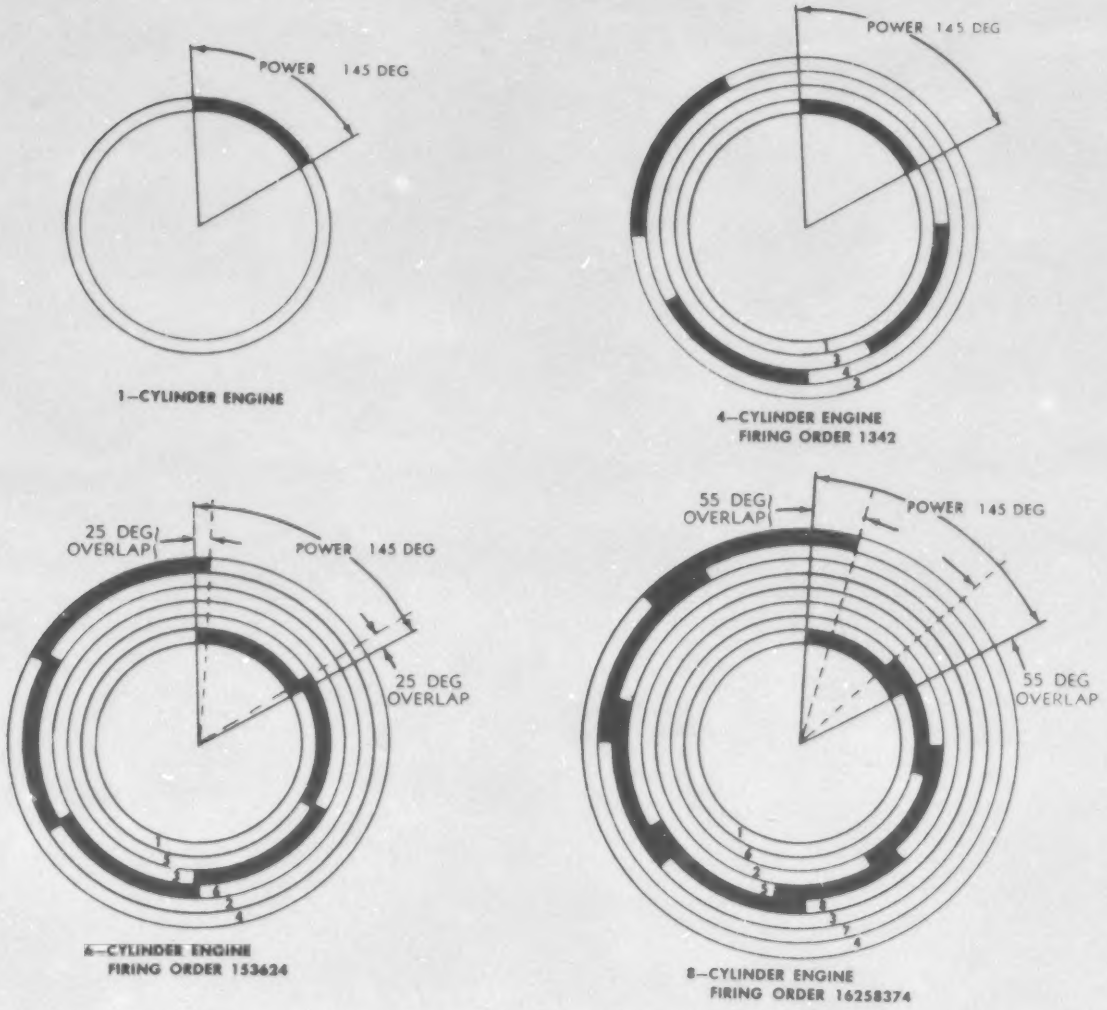
the remainder of the upward stroke of the piston. Injection begins at about 22-1/2 degrees before TDC and ends about 5 degrees before TDC, depending on the engine speed and load.

The whole cycle is completed in one revolution of the crankshaft, and the piston is ready to deliver the next power stroke.

Multiple Cylinder Engines

Theoretically, the power stroke of a piston continues for 180 degrees of crankshaft rotation on a 4-stroke cycle engine. Best results can be obtained, however, if the exhaust valves are opened when the power stroke has completed about four-fifths of its travel. Therefore, the period that power is delivered during 720 degrees of crankshaft rotation, or one 4-stroke cycle, will be 145 degrees multiplied by the number of cylinders in the engine. This may vary slightly in accordance with manufacturers' specifications. If an engine has 2 cylinders, power will be transmitted for 290 degrees of the 720 degrees necessary to complete the 4 events of the cycle. The momentum of the flywheel rotates the crankshaft for the remaining 430 degrees of travel.

As cylinders are added to an engine, each one must complete the 4 steps of the cycle during 2 revolutions of the crankshaft. The number of power impulses for each revolution also increases, producing smoother operation. If there are more than 4 cylinders, the power strokes overlap as shown in figure 5-8. The length of overlap increases with the number of cylinders. The diagram for the 6-cylinder engine shows a new power stroke starting each 120 degrees of crankshaft rotation and lasting for four-fifths of a stroke, or 145 degrees. This provides an


POWER 145 DEG
1–CYLINDER ENGINE
POWER 145 DEG
4–CYLINDER ENGINE
FIRING ORDER 1342
25 DEG OVERLAP
POWER 145 DEG
25 DEG OVERLAP
6–CYLINDER ENGINE
FIRING ORDER 153624
55 DEG OVERLAP
POWER 145 DEG
55 DEG OVERLAP
8–CYLINDER ENGINE
FIRING ORDER 16258374
NOTE –THE CIRCLES SHOWN ABOVE REPRESENT 720 DEG NOT 360 DEG BECAUSE THE CRANKSHAFT MUST ROTATE THROUGH 720 DEG TO COMPLETE THE CYCLE ONCE FOR ALL CYLINDERS

2.25

Figure 5-8.— Power strokes in 1-, 4-, 6-, and 8-cylinder engines.

overlap of 25 degrees. In the 8-cylinder engine, a power stroke starts every 90 degrees and continues for 145 degrees, resulting in a 55-degree overlap of power. Because the cylinders fire at regular intervals, the power overlap will be the same regardless of firing order, and will apply to either in-line or V-type engines.

POWER LOSSES AND FAILURE

Power failures resulting from minor troubles, such as loose or bare wires and disconnected or damaged fuel lines, usually are detected easily. Troubles like these, when reported by the operator of the equipment, eliminate much

checking and testing. You must, however, make your mechanics aware that there probably was additional trouble which was an actual or contributing cause to the power failure. You must train your men to look for this cause while making the repairs. Unless the cause of the minor trouble can be located and repaired, it may result in major trouble later.

Too often, troubles concerned with power loss occur within the engine and are not easily found. It is these hard-to-find troubles, with little or no visual indication, that keep the CMs busy. An operator may notice a decided power loss in his equipment, and because there is excessive smoke coming from the exhaust, he will report the trouble as improper carburetion, or, in the case of a diesel engine, as injector trouble.

An inexperienced mechanic may notice an increased engine temperature in addition to the exhaust smoke and diagnose the loss of power as improper valve action, or as trouble in the cooling system. These diagnoses are comparatively simple through visual indications. But, as a CM1 or CMC, you must know that there are many causes of power loss that have little or no visual indications. Examples are incorrect ignition timing, faulty coil or condenser, defective mechanical or vacuum spark advance, worn distributor cam, or slipping clutch. Any of these deficiencies can cause a power loss.

After a deficiency has been located in an engine, it is usually not too difficult to make the necessary corrections to eliminate the conditions causing the deficiency. Careful analysis and straight thinking, however, are often needed to find the cause of engine deficiencies. With a thorough knowledge of the basic engineering and operating principles of an engine your job of training your men will be much easier and more interesting. In diagnosing engine deficiencies, you must never jump to conclusions and make a decision on the nature of repairs to be made until you are sure that what will be done will eliminate the trouble. It is imperative that you be able to interpret engine instrument indications, as well as use the proper testing devices. You must be able to road-test the equipment so that you will know whether repairs have been made satisfactorily and whether a unit should be adjusted or replaced.

The CM1 or CMC should possess an unusual sense of precision in his work and must develop a systematic approach in doing a job. He must know when and how to make emergency adjustments for every unit on the engine.

It may seem that some of the qualifications required of a good mechanic point to the know-how of an automotive engineer; it is recognized, however, that no one person can know all about engines and also be an expert in repairing all kinds of powered equipment used by the SEABEES. For instance, if the checks or instrument tests indicate some internal trouble in a magneto, carburetor, or fuel injection unit, the repairs should be made by mechanics who have experience or have been specially trained to use the equipment to do the particular job at hand.

You will be expected to have the answers, or know where to find the answers, to all the questions asked by less experienced mechanics. You may be asked to prove your diagnosis of a particular trouble to a less informed but higher ranking interested person. After having done this satisfactorily, you will be glad you are "almost an engineer."

The three basic factors that affect an internal combustion engine's power are: COMPRESSION, IGNITION, and CARBURETION. In a diesel engine, the introduction of fuel into the cylinder is accomplished by injector action and ignition is dependent upon the heat of compression, while in the gasoline engine the ignition and carburetion factors are independent systems. Of course, in both engines proper action and timing of all three factors are necessary for the engine to produce its rated power.

From the foregoing discussion about power, it is obvious that an engine runs and develops rated power if all of its parts function or operate as they should. If any of these parts wear or break, requiring replacement or adjustment, the performance charts and engine specifications are "tools" that will help you bring those parts back to their original relationship to each other.

There are a few more factors not directly associated with engine working parts that must be considered in correcting engine power losses.

OPERATING CONDITIONS can affect engine power. For example, the usable horsepower of an engine is reduced by the number of accessories it must operate. If the engine is required to provide power for lifting operations at the same time it is delivering power to wheels or tracks, the engine may be overloaded and may not be able to develop its rated rpm; consequently, the rated horsepower would not be reached.

The effect of ALTITUDE on engine power must also be considered. As a rule, 2-1/2 percent of the output of an engine is lost for every

1,000-foot increase in elevation above sea level. Overheated air entering the cylinders has the same effect on engine power as an increase in altitude. In computing horsepower output, engineers will deduct as much as 1 percent for each 10 degrees F rise in the intake air temperature above a "normal" temperature of 70°F.

DIAGNOSING ENGINE PROBLEMS

Diagnosing may be defined, for our purpose, as a systematic means of identifying a problem by utilizing all available information and facts. Usually, the Equipment Operator will be able to tell you the symptoms, such as the engine lacks power, uses excessive oil, has low oil pressure, or makes certain noises.

Some internal engine problems may be found by listening for unusual noises and knocks or by examining the exhaust gases for indications of incomplete combustion. Then too, placing an artificial load on an engine can emphasize certain noises. For example, applying the brakes and partially engaging the clutch with the vehicle transmission in high gear. In this manner you can hear the engine operating under a load without the interference of body noises.

There are other tricks of the trade that a mechanic may also use, such as feeling the oil or shorting out the spark plugs, to give him an idea of the source of trouble.

EXCESSIVE OIL CONSUMPTION

There are two main causes of excessive oil consumption: by burning in the combustion chamber and by external leakage. Excessive oil consumption would probably first be noted by the operator who has to add an excessive amount of oil to maintain the proper oil level.

External oil leaks can often be detected by inspecting the seals around the oil pan, valve covers, timing gear housing, and at the oil line and oil filter connections.

The burning of oil in the combustion chamber usually produces a bluish tinge in the exhaust gas. Oil may enter the combustion chamber in three ways: through a cracked vacuum pump diaphragm when the vehicle is equipped with a combination fuel and vacuum pump; through clearances caused by wear between the intake valve guides and stems; and around the piston rings.

Excessive oil consumption caused by worn valve guides or stems may be detected by excessive amounts of carbon on the undersides of the intake valves. When this condition is found, it is usually necessary to install valve seals, new valve guides, or new valves. If excessive oil consumption is caused by worn rings or worn cylinder walls, you will probably have to have your mechanics do a complete engine overhaul.

LOW OIL PRESSURE

Low oil pressure is often an indication of worn engine bearings. The bearings can pass so much oil that the oil pump cannot maintain oil pressure. Other causes of low oil pressure include a weak relief-valve spring, a worn oil pump, a broken or cracked oil line, or a clogged oil line. Oil dilution, foaming, sludge, insufficient oil, or oil made too thin by the engine overheating will also cause low oil pressure.

ENGINE NOISES

A variety of engine noises may occur, some of which have little significance. Other noises can indicate serious engine trouble that will require prompt attention to prevent major damage to the engine.

A listening rod can be of help in locating the source of a noise. The rod acts somewhat like the stethoscope a doctor uses to listen to a patient's heartbeat or breathing. When one end is placed at the ear and other end at some particular part of the engine, noises from that part of the engine will be carried along the rod to your ear. By determining the approximate source of the noise, you can, for example, locate a broken or noisy ring in a particular cylinder or a main bearing knock. CAUTION: Keep clear of the fan belt and fan blades when using a listening rod.

Valve and Tappet Noise

Valve and tappet noise is a regular clicking sound that increases in intensity as the engine speed increases. The cause is usually excessive valve clearance. A feeler gage inserted between the valve stem and lifter or rocker arm will reduce the clearance and the noise should decrease. If the noise does not decrease when the feeler gage is inserted, it is probably caused by weak lifter springs, worn lifter faces, lifters loose in the block, a rough adjustment-screw face, a rough cam lobe, or possibly the noise is not from the valves at all.

A noisy hydraulic valve lifter may be sticking because of dirt in the ball or disk valve. When this happens, you must dissassemble the lifter and clean all the parts in a clean solvent. Then reassemble the lifter and fill it with clean, light engine oil.

Connecting Rod Noises

Connecting rod noises usually have a tendency to give off a light knocking or pounding sound. The sound is more noticeable when the engine is "floating" (not accelerating or decelerating) or as the throttle is eased off with the vehicle running at medium speed. To locate a noise in the connecting rod, short out the spark plugs one at a time. The noise will be greatly reduced when the piston in the cylinder that is responsible is not delivering power.

Piston-Pin Knock

Piston-pin knock is identified more as a metallic double-knock rather than a regular clicking sound like that heard in valve and tappet noise. In addition, it is most noticeable during idle with the spark advanced. A check can be made by idling the engine with the spark advanced and then shorting out the spark plugs. Piston-pin noise coming from a cylinder will be reduced somewhat when the spark plug for that cylinder is shorted out. Causes of this noise are a worn or loose piston pin, a worn bushing, and a lack of oil.

Piston Ring Noise

Piston ring noise is also similar to valve and tappet noise, since it is identified by a clicking, snapping, or rattling sound. This noise is most noticeable on acceleration. Low ring tension, broken or worn rings, or worn cylinder walls will produce this sound. To avoid confusing this sound with other engine noises make the following test: Remove the spark plugs and add an ounce or two of heavy engine oil to each cylinder. Crank the engine for several revolutions to work the oil down past the rings. Replace the spark plugs and start the engine. If the noise has decreased, it is probable that the rings are at fault.

Piston Slap

Piston slap may be detected by a hollow, bell-like knock and is due to the rocking back and forth of the piston in the cylinder. If it occurs only when the engine is cold, it is probably not serious. However, if it occurs under all operating conditions, it must be further investigated. It can be caused by worn cylinder walls, worn pistons, collapsed piston skirts, or misaligned connecting rods.

Crankshaft Knock

Crankshaft knock is a heavy, dull, metallic knock that is noticeable when the engine is under load or accelerating. When the noise is regular, it can be contributed to worn main bearings. When the noise is irregular and sharp, then it is probably due to worn thrust bearings.

TESTING

An experienced mechanic may come up with the right answer by listening to engine noises, but all too often this is a hit or miss procedure. When he misses he will come to you for an answer to his problem. To save time and get accurate results, tests have been developed that enable you to locate and identify engine problems. Three of the most widely used tests are the COMPRESSION, VACUUM, and CYLINDER LEAKAGE tests.

Compression Test

As you have learned, engine power is the result of igniting a combustible mixture which has been compressed in the combustion chamber of an engine cylinder. The tighter a given volume of fuel mixture is squeezed in the cylinder before it is ignited, the greater the power developed. Unless approximately the same power is developed in each cylinder, the engine will run unevenly. By measuring compression pressures of all cylinders with a compression gage, then comparing them with each other and with the manufacturer's specifications for a new engine, you get an accurate indication of engine condition.

The compression pressures in the different cylinders of an engine may vary as much as 20 pounds. The variation is caused largely by the lack of uniformity in the volume of the combustion chamber. It is nearly impossible to make all the combustion chambers in a cylinder head exactly the same size. For example, in a given engine with a 7 to 1 compression ratio with all combustion chambers the same volume, the compression pressure would be about 120 pounds in all cylinders. However, if one combustion

chamber is 1/3 cubic inch too small, the pressure will be about 126 pounds, and if it is 1/3 cubic inch too large, the compression pressure would be about 114 pounds. This is a variation of 12 pounds. Note, also, that a carbon deposit will raise the compression pressure at any given ratio by reducing the combustion chamber volume. The greater the deposit, the higher the pressure.

To make a compression test, first warm up the engine. This warm-up period will allow all the engine parts to expand to normal operating condition and will ensure a film of oil on the cylinder walls. You will remember that the oil film of the walls of the cylinder helps the expanded piston rings to seal the compression within the cylinder. After the engine is warmed to operating temperature, shut it down and remove all the spark plugs. Removing all the plugs will make the engine easier to crank while you obtain compression readings at each cylinder. The throttle and choke should be in a wide open position when compression readings are taken. Some compression gages can be screwed into the spark-plug hole. Most compression gages, however, have a tapered rubber end plug and must be held securely in the spark-plug opening until the highest reading of the gage is reached. Normal compression readings for gasoline engine cylinders are usually 100 psi, or slightly higher.

A compression test can be accomplished faster and safer if there are two men assigned to the job. Remember that you must complete the compression test before the engine cools off.

Unless you can make an intelligent interpretation of the compression readings, it is useless to make the tests. Any low readings indicate a leakage past the valves, piston rings, or cylinder head gaskets. Before taking any corrective action you should make one further check to more accurately pinpoint the trouble. Pour a small quantity of heavy oil into the cylinder through the spark plug hole, and then retest the compression pressure. If the pressure increases to a more normal reading this means the loss of compression is due to leakage past the piston rings. If adding oil does not help compression pressure, the chances are that the leakage is past the valves. Low compression between two adjacent cylinders indicates a leaking or blown head gasket. If the compression pressure of a cylinder is low for the first few piston strokes, then increases to a near normal racing, a sticking valve is indicated. Near normal compression readings on all cylinders indicate that the engine cylinders and valves are in fair condition. Indications of valve troubles by compression tests may be confirmed by taking vacuum gage readings.

Vacuum Test

When you get abnormal compression readings in an engine, it is likely that the cylinder head will have to be removed to repair the trouble. Nevertheless, you should have one of your men test the vacuum of the engine with a gage. When a vacuum gage is operated and observed by an experienced mechanic, it will provide considerable information about the internal condition of the engine. The action of the pointer on the gage is the most important factor in interpreting the reading to determine the internal trouble of the engine.

Vacuum gage readings are taken with the engine running and must be accurate to be of any value. Therefore, when connecting the gage to the intake manifold, be sure the connection is leakproof. Also, before the connection is made, see that the openings to the gage and intake manifold are free from dirt or other restrictions.

When a test is made at an elevation of 1,000 feet or less, an engine in good condition, idling at a speed of about 550 rpm, should give a steady reading of from 17 to 22 inches on the vacuum gage. The average reading will drop approximately 1 inch of vacuum per 1,000 feet at altitudes of 1,000 feet and higher above sea level.

Upon opening and closing the throttle suddenly, the vacuum reading should first drop to about 2 inches with the throttle open, and come back to a high of about 24 inches before settling back to a steady reading as the engine idles. This is normal for an engine in good operating condition.

If the gage reading drops to around 15 inches and remains there, it would indicate compression leaks between the cylinder walls and the piston rings, or power loss caused by incorrect ignition timing. A vacuum gage pointer indicating a steady 10, for example, usually means that the valve timing of the engine is incorrect. Below normal readings that change slowly between two limits, such as 14 and 16 inches, could point to a number of troubles. Among them are improper carburetor idling adjustment, maladjusted or burned breaker points, and spark plugs with the electrodes set too closely.

A sticking valve could cause the gage pointer to bounce from a normal steady reading to a lower reading and back to normal. A broken or weak

valve spring would cause the pointer to swing widely as the engine is accelerated. A loose intake manifold, or a leaking gasket between the carburetor and manifold, would show a steady low reading on the vacuum gage.

You must remember that vacuum gage tests only help you to locate trouble. They are not always conclusive, but as you gain experience in interpreting the readings, you can usually diagnose engine behavior.

Cylinder Leakage Test

Another aid in locating compression leaks is the cylinder leakage test. The principle involved is that of simulating the compression that develops in the cylinder during operation. Compressed air is introduced into the cylinder through the spark plug or injector hole, and by listening and observing at certain key points basic deductions can be made.

There are commercial cylinder leakage testers available, but actually the test may be conducted with materials readily available in most repair shops. In addition to the supply of compressed air, a device for attaching the source of air to the cylinder is required. For a gasoline engine, this device can be made by using an old spark plug, of the correct size for the engine to be tested. By removing the insulator and welding a pneumatic valve stem to the spark plug's threaded section, we now have our device for introducing the compressed air into the cylinder.

The next step is to place the piston at top dead center (TDC) or "rock" position between the compression and power strokes. The compressed air may then be introduced into the cylinder. Now, by listening at the carburetor, the exhaust pipe, and the oil filler pipe (crankcase), and by observing the coolant in the radiator, when applicable, we can pinpoint the area of air loss. A loud hissing of air at the carburetor would indicate a leaking intake valve or valves. Loud hissing of air at the exhaust pipe would indicate a leaking exhaust valve or valves. Excessive hissing of air at the oil filler tube (crankcase) would indicate an excessive air leak past the piston rings. Bubbles observed in the coolant at the radiator would indicate a leaking head gasket.

A point to note is that the engine will have a tendency to spin when the air pressure is applied to the cylinder.

Bear in mind that the above indications are not conclusive. For instance, the leading head gasket may prove to be a cracked head, or the "bad rings" may be a scored cylinder wall. *The important fact is that* the source of trouble has been pinpointed to a specific area, and a fairly accurate broad estimate of the repairs or adjustments required can be made without dismantling the engine.

In making a cylinder leakage test, all of the spark plugs are removed so that the cranking of the engine, to position the piston of the cylinder to be tested, may be accomplished without the resistance of compression of the remaining cylinders. The commercial testers, such as the one shown in figure 5-9, have a gage indicating a percentage of air loss. The gage is connected to a spring-loaded diaphragm. The source of air is connected to the instrument and counterbalances the action of the spring against the diaphragm. By adjusting the spring tension, the gage may be properly calibrated against a variety of air pressure sources within a given tolerance.

Gage Care and Maintenance

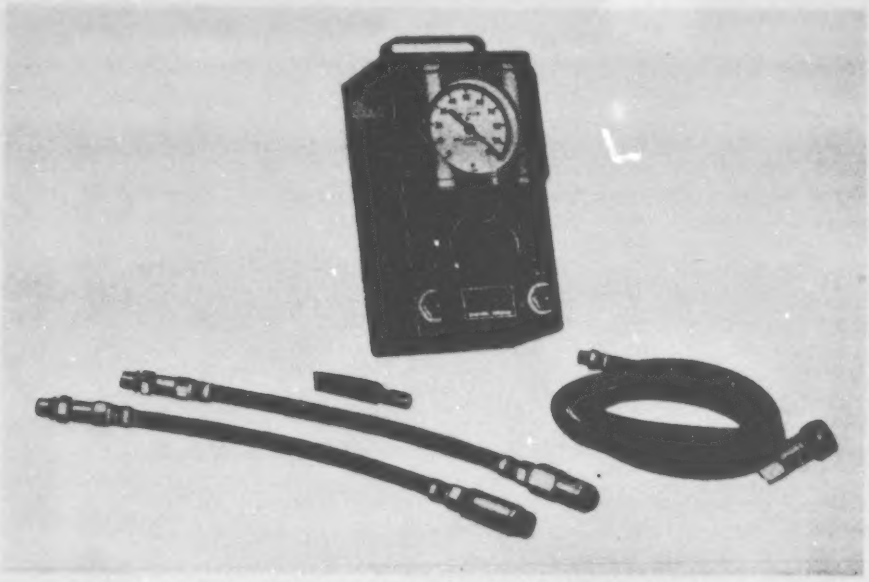
As a CM1 or CMC, you will probably be responsible for the care and maintenance of the compression and vacuum gages and the commercial cylinder leakage testers. You must impress upon your men that these gages and testers are fragile instruments that can be damaged through improper use or rough handling. They should be kept in a safe place in the toolroom and should be returned there immediately after being used. Keeping the gages and testers clean is about all the maintenance that is required. If they are dropped, broken, or jarred out of calibration, it is generally necessary to return them to the manufacturer for repairs.

SERVICING VALVES, VALVE MECHANISMS, AND CYLINDER HEADS

When an engine has been properly maintained and serviced, its first major repair job will normally involve the valves. A general procedure for servicing valves is described in Construction Mechanic 3 & 2. Here, we will go into more detail on the servicing of valves, valve mechanisms, and their troubleshooting.

VALVE TROUBLES

Some of the common valve troubles that you may encounter in working with engines, and



81.2X

Figure 5-9.—Cylinder leakage tester.

possible causes of these troubles are indicated below.

1. Sticking valves may be caused by gum or carbon deposits, worn valve guides, a warped valve stem, insufficient oil, cold engine operation, or overheating.

2. Valve burning may be induced by a valve that is sticking, insufficient valve tappet clearance, a distorted seat, overheated engine, lean fuel-air mixture, preignition, detonation, or valve seat leakage.

3. Valve breakage may occur by valve overheating, detonation, excessive tappet clearance, seat eccentric to stem, cocked spring or retainer, or scratches on the stem due to improper cleaning.

4. Valve face wear may be caused by excessive tappet clearance, dirt on the face, or distortion.

5. Valve deposits may be produced by gum in the fuel, a rich fuel mixture, poor combustion, worn valve guides, dirty oil, or use of a wrong oil.

VALVE ADJUSTMENTS

Proper and uniform valve adjustments are required for a smooth running engine. Unless the clearance between valve stems and rocker arms or valve lifters is adjusted in accordance with the manufacturer's specifications, the valves will not open or close at the proper time and engine performance will be affected. Too great a clearance will cause the valves to open late. Valves adjusted with too little clearance will overheat and warp. Warped valves cannot seat properly and will permit the escaping combustion flame to burn both the valve and valve seat. Too great a clearance may also prevent a valve from opening far enough and long enough to admit a full charge of air or fuel mixture (with either a diesel or gasoline engine), or it will prevent the escape of some exhaust gases from the cylinder. A reduced charge in the cylinder obviously results in engine power loss. Exhaust gases that remain in the cylinder take up space, and when combined with the incoming charge they reduce the effectiveness of the mixture.

When you have reassembled an engine after reconditioning the valves, make sure the adjusting screws are backed off before rotating the engine. A valve that is too tight could strike the piston and either damage the piston or the valve, or both. Adjust the valves in accordance

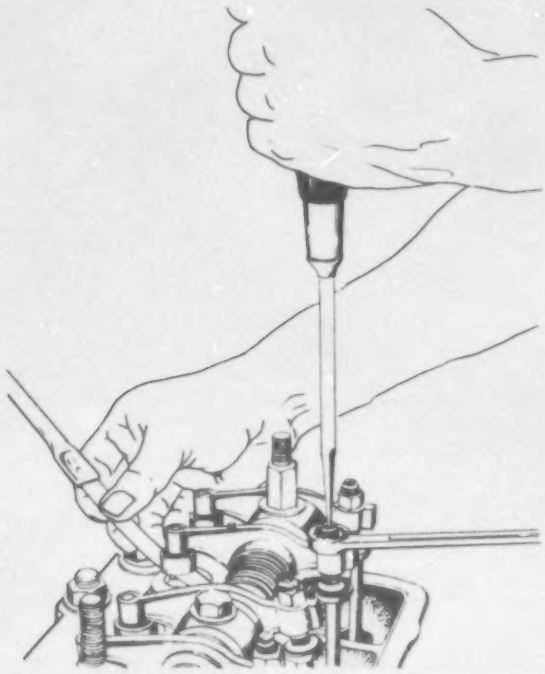
with the manufacturer's specifications, following recommended procedure.

On any engine where valve adjustments have been made, be sure the adjustment locks are tight, and that the valve mechanism covers and gaskets are in place and securely fastened to prevent oil leaks.

Overhead Valves

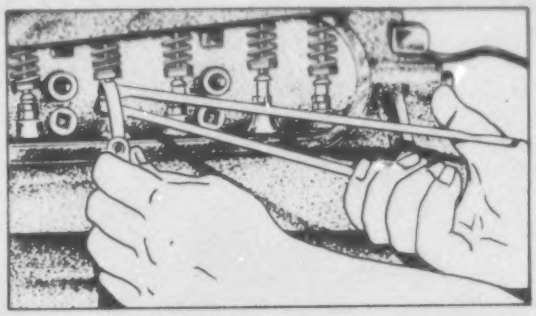
Most overhead valves are adjusted "hot"; that is, valve clearance recommendations are given for an engine at operating temperatures. Before valve adjustments can be properly effected, the engine must be run and brought up to normal operating temperature.

To adjust a valve remove the valve cover and measure the clearance between the valve stem and the rocker arm. Loosen the locknut and turn the adjusting screw in the rocker arm as shown in figure 5-10. On engines with steel-supported rocker arms, the adjustment is made by turning the studnut.



2.475

Figure 5-10.—Adjusting overhead valves.



2.476

Figure 5-11.—Adjusting valve in block.

Valves in Block

Valves within the block are generally adjusted "cold"; that is, recommended valve clearances are given for a cold engine. These valves have mechanisms very much like overhead valves and are adjusted by removing side plates usually found beneath the intake manifold on the side of the engine block (fig. 5-11). Since this engine must be stopped to adjust the valves, the piston in the cylinder to be adjusted must be on top dead center of the compression stroke. This can be determined by watching the valves of the piston that is paired with the one that is being set. As the cylinder that is being positioned is coming up on the compression stroke, the paired cylinder will be coming up on the exhaust stroke. Therefore, an exhaust valve will be open. Just as the exhaust valve closes and the intake valve begins to open, the cylinder that is to be set will be on top dead center of the compression stroke and the two valves can be set. Once number one cylinder is positioned, follow through according to the firing order of the engine, as this makes the job much easier and faster. This procedure may also be used when adjusting valves on overhead valve engines.

Hydraulically Operated Valves

On engines equipped with hydraulic valve lifters (fig. 5-12), it is not generally necessary to adjust the valves periodically. The engine lubrication system supplies a flow of oil to the lifters at all times. These hydraulic lifters operate at zero clearance and compensate for

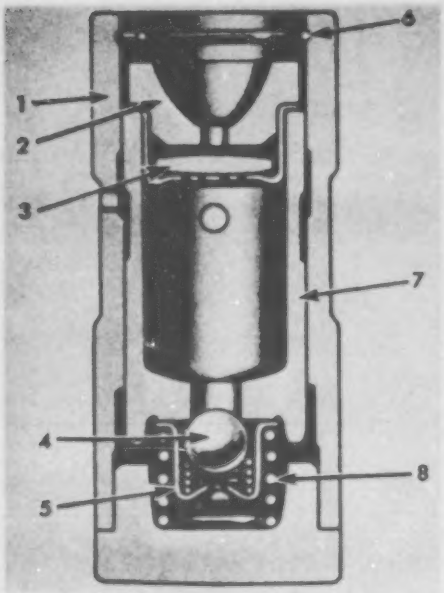


Figure 5-12.—Hydraulic valve lifter. 2.38X

changes in engine temperature, adapt automatically for minor wear at various points, and thus provide ideal valve timing.

The first indication of a faulty hydraulic valve lifter is a "clicking" noise. One method for locating a noisy valve lifter is by using a piece of garden hose. Place one end of the hose near the end of each intake and exhaust valve, and the other end of the hose to the ear. This localizes the sound, making it easy to determine which lifter is at fault. Another method is to place a finger on the face of the valve spring retainer. If the lifter is not functioning properly, a distinct shock will be felt when the valve returns to its seat.

Usually, where noise exists in one or more of the valve lifters, all lifter units should be removed, cleaned in a solvent, reassembled, and reinstalled in the engine. If dirt, carbon, or the like, is found in one unit, it more than likely is present in all of them; and, it will only be a matter of time before the rest of the lifter units will give trouble.

VALVE REMOVAL

For such services as valve or valve seat grinding, valve seat insert replacement, and valve guide cleaning or replacement, the cylinder head and valves must be removed from the engine. Extreme care must be exercised to avoid interchanging valves; each valve must be replaced in the valve port from which it was removed. A valve rack in which the valves may be placed in their proper order—along with their valve springs, retainers, and locks—is normally provided. Different tools and procedures for removal are used for different engines. Check the manufacturer's maintenance manual for your particular engine.

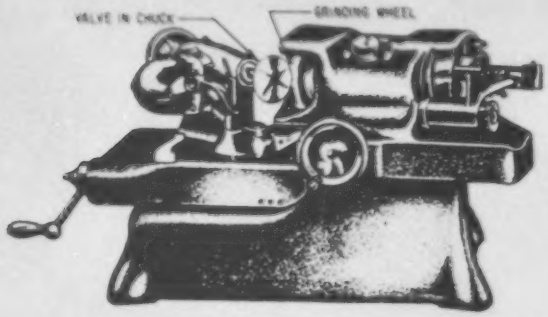
GRINDING VALVES

The first step in servicing valves after they have been removed from the engine is to rid them of carbon. The best method for doing this is cleaning with a wire buffing wheel or brush.

CAUTION: When using the wire buffing wheel, always wear goggles to protect your eyes from wire or carbon that may fly off the buffing wheel.

After the cleaning process, inspect each valve to determine whether it can be serviced and reused or must be replaced. The valve should be checked with a runout gage for eccentricity and inspected for worn valve stem and badly cracked, burned, or pitted valve face. Minor pits, burns, or irregularities in the valve face may be removed by grinding.

To grind valves, clamp the valve stem in the chuck of the valve-refacing machine so that the face of the valve will contact the grinding wheel. (See fig. 5-13.) Set the chuck at the proper angle to give the correct angle to the setting face. This angle must just match the valve seat angle. It is becoming common, however, in some engines to reface the valve at a slightly flatter angle than the seat, usually 1/4 to 1 degree to provide what is known as an "interference angle." This angle provides greater pressure at the upper edge of the valve seat which aids in cutting through any deposits that form and provides for better sealing. Some engines use the interference angle on the exhaust valve only and others use it on both the intake and exhaust valves.

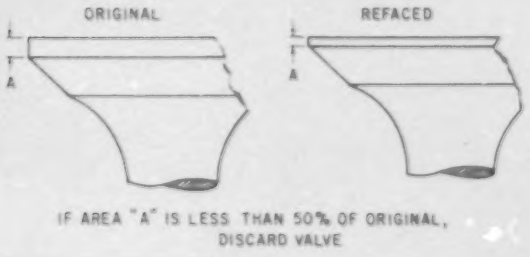


81.9
Figure 5-13.—Valve refacing machine.

Check the manufacturer's manual for the recommended angle for both valve and valve seat.

CAUTION: Due to the different angles between the valve and the valve seat, grinding compound cannot be used to finish the surface.

At the start of the grinding operation, make the first cut a light one. If metal is removed from only one-third or one-half of the valve face, check to make sure you have centered the valve in the chuck. If the valve is improperly centered, then the valve stem is bent and the valve must be replaced. Remove only the amount of metal necessary to true up the face and remove the pits. Make sure there is proper margin of thickness as indicated in figure 5-14. If this margin cannot be retained after refacing, then the valve must be discarded.



2.478
Figure 5-14.—Proper valve margin of thickness after refacing.

There are many different makes and models of valve refacing machines. Make sure that you read and understand the instructions that apply to the machine you are using.

GRINDING VALVE SEATS

Two general types of valve seat grinders are in use. One is a concentric grinder, the other an eccentric grinder. Only the concentric grinder is discussed here because of its greater availability.

In the concentric valve-seat grinder (fig. 5-15), a grinding stone of the proper shape and angle is rotated in the valve seat. The stone is

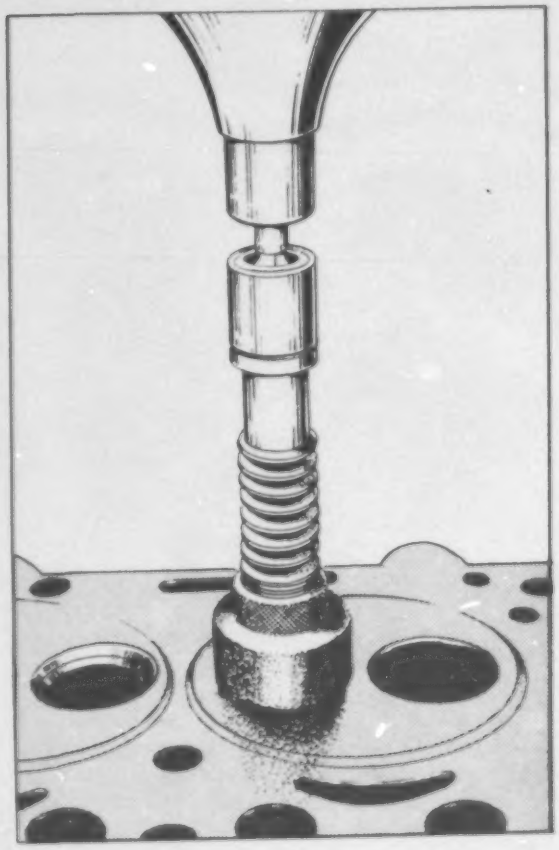


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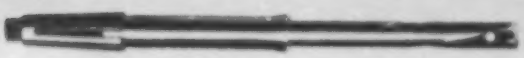
Figure 5-15.—Grinding valve seats using a concentric type of grinder.



2.29X

Figure 5-16.—Self-centering pilot.

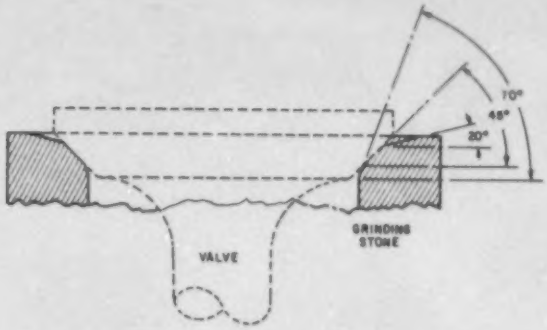
kept concentric with the valve guide by means of a self-centering pilot (fig. 5-16) which is installed in the valve guide. The valve guide must be kept clean and in good condition. Most of the Navy's concentric grinders automatically lift the stone off the valve seat about once every revolution to allow the stone to clean itself of dust and grit by centrifugal action.

The abrasive stone must be dressed frequently with a diamond-tipped dressing tool, such as that illustrated in figure 5-17. Dressing the stone will ensure a uniform, even grinding of the valve seat.

After the seat is ground, it will be too wide. It must be narrowed by using upper and lower grinding stones to grind away the upper and lower edges of the seat. Figure 5-18 shows a typical valve seat that was ground at 45 degrees,

2.480

Figure 5-17.—Stone dresser.



2.481

Figure 5-18.—Valve contact correction.

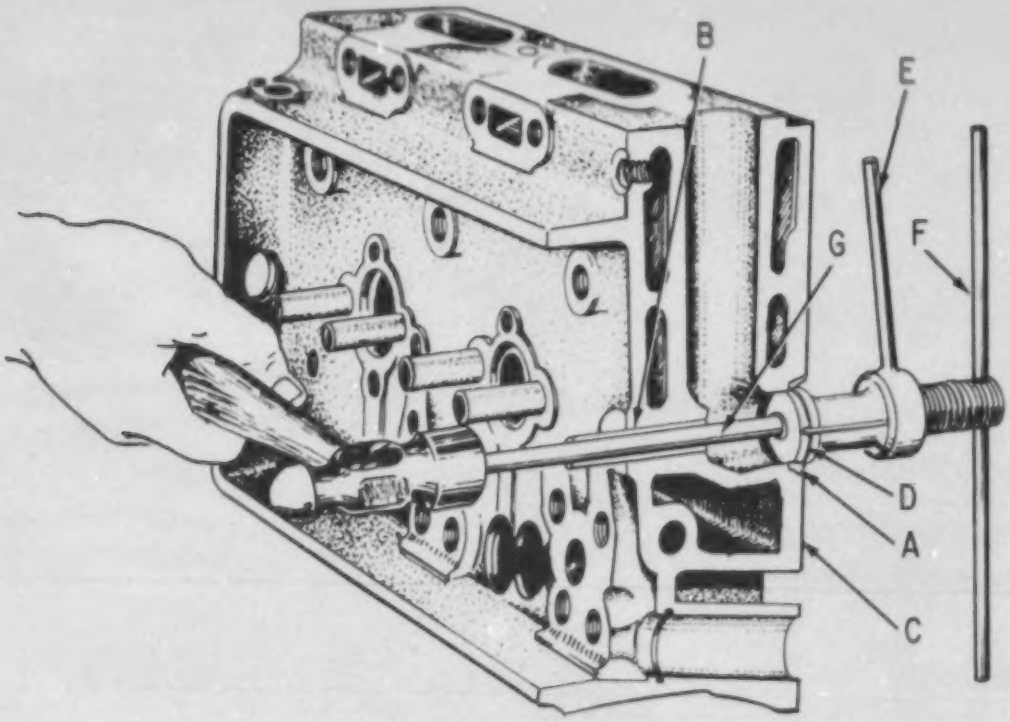
then narrowed at the top with a 20-degree grinding stone, and then ground at the bottom with a 70-degree grinding stone to narrow and center the valve seat.

To test the contact between the valve seat and the valve, mark lines with a soft pencil about one-fourth inch apart around the entire face of the valve. Next, put the valve in place and rotate, using a slight pressure, one-half turn to the right and then one-half turn to the left. If rotating removes the pencil marks, the seating is good.

In another method for checking the valve seating, the valve face is coated lightly with Prussian blue and turned about 1/4 turn in the seat. If the Prussian blue transfers evenly to the valve seat, it is concentric with the valve guide. All the Prussian blue should be washed from the seat and valve. The valve seat should then be lightly coated with Prussian blue. If the blue again transfers evenly, this time to the valve when it is turned in the seat, the seating can be considered normal.

REPLACING VALVE SEAT INSERTS

Some engines are equipped with valve seat inserts that may be replaced when they are badly worn or burned, or have been ground down to where insufficient metal remains to permit another grind. The old valve seat may be removed by using a special puller such as the one shown in figure 5-19. However, if a puller is not available, you can punchmark each side of the insert and then drill almost through. After drilling, take a hammer and chisel and break the insert into halves for easy removal.



A. Insert, Valve Seat
B. Guide, Exhaust Valve
C. Cylinder Head
D. Collet
E. Handle, Collet
F. T Handle
G. Bar, Drive

2.482

Figure 5-19.—Puller used in removing valve seat inserts.

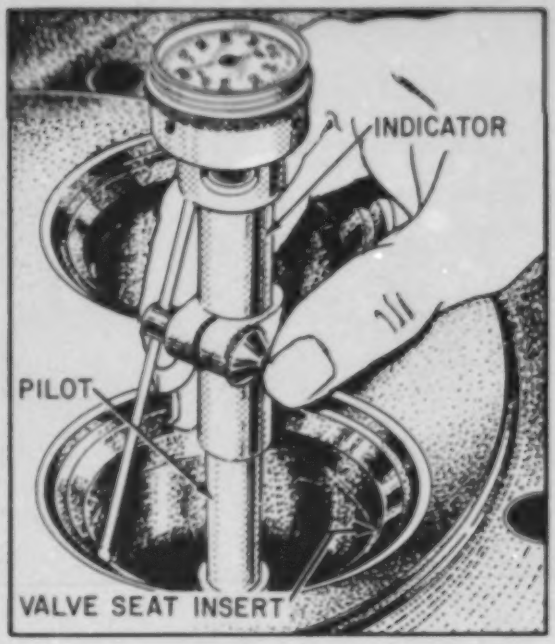
Before installing a new insert, chill it for 15 minutes in dry ice or by any other chilling method. Chilling shrinks the insert so that it will fit in place. It may then be driven in place and the seat ground.

SERVICING VALVE GUIDES

When servicing valve guides, remember that the guides must be clean and in good condition for normal valve seating. If, after cleaning a valve guide, you find it worn, remove and install a new one. To remove old or worn valve guides and install new ones, special guide removing and replacing tools are required.

One procedure for checking valve guide wear in an L-head engine involves the use of a dial indicator (fig. 5-20). With the valve in place, turn the engine over so that the valve is moved off its seat. Install the dial indicator on the block with the indicating button touching the edge of the valve head. Move the valve sideways to determine the amount of wear. Almost the same procedure may be used on an I-head engine—except that the valve must be held off its seat while the guide is checked for wear.

Another checking procedure involves the use of a small hole gage to measure the inside diameter of the guide and a micrometer to measure the valve stem: the difference in the readings will be the clearance. When the maximum clearance is exceeded, the valve guide needs further servicing before you can proceed. If of the integral type, the valve guide must be reamed



75.73

Figure 5-20.—Determining concentricity of the valve seat with a dial indicator.

to a larger size and a valve with an oversized stem installed. But if the guide is replaceable, it should be removed and another one installed.

To remove valve guides you will need a special puller. On many L-head engines the guides may be driven down into the valve spring compartment and then removed. When guides are removed from overhead type engines, an arbor press may be used.

To replace the guides you will use a valve guide driver or a valve guide replacer, except on overhead valve engines where an arbor press is necessary. In any case the guides must be installed to the proper depth in either the block or head as specified by the manufacturer.

After the valve guides are serviced and the valve seats ground, check the concentricity of the two with a dial indicator (see fig. 5-20). Any irregularity in the seat will register on the dial.

SERVICING ROCKER ARMS

After removing rocker arms, inspect them for wear or damage. Rocker arms which are equipped with bushings may be rebushed if the old bushing is only worn. As you know, the worn valve on slightly worn rocker arm ends can be ground down on a valve refacing machine, whereas excessively worn rocker arms should be discarded.

When installing rocker arms and shafts in the cylinder head, make sure that the oil holes (in shafts so equipped) are on the underside so that they will feed oil to the rocker arms. If springs and rocker arms are suitable for continued use, they should be reinstalled in their original positions in the head.

TESTING VALVE SPRINGS

Valve springs should be tested for uniform height and proper tension. To test for uniformity of height, place the used springs on a level surface beside a new pair of springs. Use a straightedge to determine any differences in height. Unequal or cocked valve springs may cause faulty valve and engine performance.

The preferred method of testing valve springs for proper tension is by using a valve spring tester. The pressure required to compress the spring to the proper length is measured in accordance with the manufacturer's specifications.

SERVICING VALVE LIFTERS

There are two types of valve lifters: the solid type and the hydraulic type. Procedures for removing and servicing the two types are quite different.

Solid lifters are removed from the camshaft side on some engines. This requires removal of the camshaft. The lifters must be held up by clips or wires so that the camshaft can be extracted. Then the clips or wires are removed so that the lifters may be extracted. Most valve lifters may be extracted from the pushrod or valve side of the engine block, in which case extraction of the camshaft is not necessary. Be sure to keep the lifters in the proper order so that they may be replaced in the same bores from which they were removed.

If the lifter-screw face is worn or pitted, it may be refaced on a valve-refacing machine. If the lifter bore in the block becomes worn, it may be rebored by reaming; then oversized lifters must be installed.

Hydraulic lifters on some engines are tested by the leak down rate test. In testing, insert a feeler gage between the rocker arm and the

valve stem and note the time it takes the valve lifter to leak enough oil to permit the valve to seat. As the valve seats, the feeler gage becomes loose and signals the end of the test. If the leak down rate time is too short, the lifter is defective and must be replaced. In any case, be sure to follow the manufacturer's recommended procedures for performing this test.

To remove hydraulic lifters, remove the pushrod cover and the rocker arm assembly and take out the pushrod. On engines with shaft mounted rocker arms, the rocker arm may be moved by compressing the spring so that the pushrod can be removed. Thus, the rocker arm assembly does not have to be removed.

After the lifter has been removed, check the bottom or cam side to ensure that it is flat. To do this, place a straightedge across the lifter bottom. If light can be seen between the straightedge and the lifter, the lifter should be discarded.

When you dissassemble the lifter, be sure to clean all parts in a cleaning solvent. Reassemble and fill the lifter with clean, light engine oil. Also, make sure that all lifters are replaced in the same bores from which they were removed. Work on one lifter at a time so that parts are not mixed between lifters.

CHECKING THE CAMSHAFT

The camshaft must be checked for bearing-journal or cam wear and alignment. In checking alignment, place the camshaft in a set of V-blocks and use a dial indicator to check the run-out of the journals when the shaft is turned. Journals should be checked with a micrometer and the reading compared to the manufacturer's specifications. The cam wear should be measured with a micrometer; however, if wear shows across the full face of the cam you can be almost certain that excessive wear has taken place.

REPLACING CAMSHAFT BEARINGS

When camshaft bearings are worn or show excessive clearance, they should be replaced. Special tools are required to remove and replace cam bearings. When installing new bearings, be sure that the oil holes are aligned with those in the block. Make sure, also, that new bearings are staked in the block if the old bearings were staked. On some engines which do not use precision-insert bearings, line reaming of the bearings is required after they have been installed.

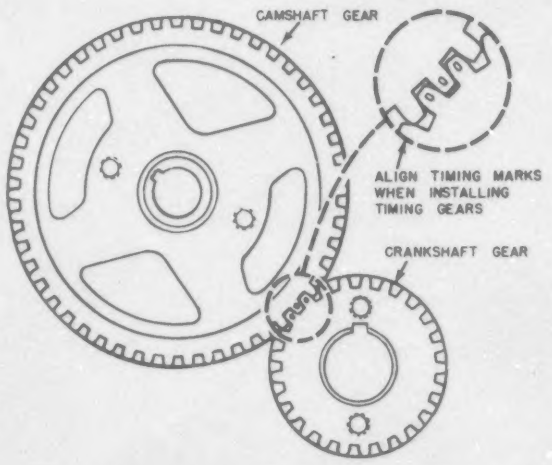


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Figure 5-21.—Timing gears and their markings.

TIMING THE VALVES

The relationship between the camshaft and crankshaft determines the valve timing. Sprockets and chains are used to open and close the valves in relation to the position of the pistons in the cylinders.

The gears or sprockets, as the case may be, of the camshaft and crankshaft are keyed in position so they cannot slip. Since they are keyed to their respective shafts, they can be replaced if they become worn or noisy.

With directly driven timing gears (fig. 5-21), one gear usually has a mark on two adjacent teeth and the other a mark on only one tooth. To time the valves properly, it is necessary to mesh the gears so that the two marked teeth of the one gear straddle the single marked tooth of the other gear.

In the case of chain-driven sprockets, correct timing may be obtained by having a certain number of chain-link teeth between the marks, or by lining up the marks with a straightedge as shown in figure 5-22. In the latter method, the position of the piston is determined by the markings on the flywheel. Some engines have timing marks on the crankshaft pulley if there is no opening provided in the flywheel housing. Always check the manufacturer's instructions when you are in doubt about the method of timing the engine you are overhauling.

81.70

Figure 5-22.—Methods of valve timing with a chain drive.

SERVICING THE CRANKSHAFT AND CYLINDERS

Most modern engines have main and connecting rod bearings of the precision insert type, which can be replaced without removing the crankshaft. However, if oil passages are blocked, journals are tapered out of round, or the crankshaft is bent, simply replacing the bearings will not correct the trouble.

If the bearings appear to have worn uniformly, probably the only requirements are crankshaft journal checks and bearing replacement. If bearing wear is uneven, then the safest procedure is to remove the crankshaft from the engine and check it.

CHECKING CRANKSHAFT JOURNALS AND BEARINGS

There are two methods of measuring crankshaft journals. One method requires the use of a bridge gage of the type shown in figure 5-23; the other method requires an outside micrometer. Regardless of the method used, take several measurements along the journal to check for taper. Also, rotate the crankshaft one-quarter or one-eighth turn at a time so additional measurements can be taken to check out of round wear. Journals that are tapered or out of round by more than .003 inch must be reground.

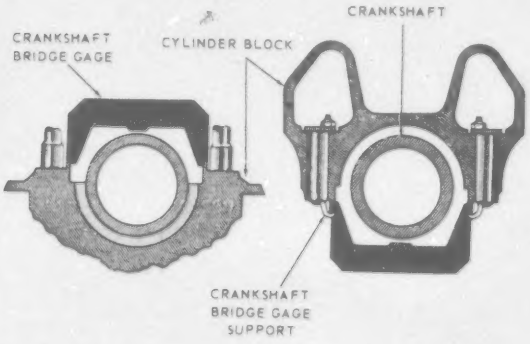

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Figure 5-23.—Crankshaft bridge gage.

REMOVING BEARING CAPS

When removing bearing caps, make sure you mark them so they can be replaced on the same journals from which removed. If the bearing caps stick, carefully work them loose to avoid distorting them. When a bearing cap puller is used, the puller bolt is screwed into the oil-coupling bore hole of the journal allowing the cap to be removed. Another method of removing the bearing cap is to work it loose by tapping the cap lightly on one side and then the other side with a brass hammer.

CHECKING BEARING FIT

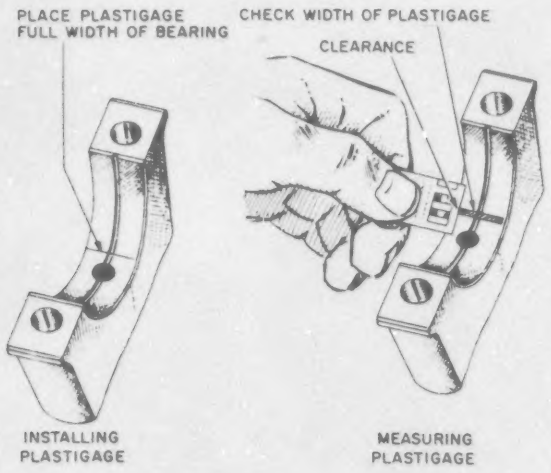
Bearing fit or oil clearance should always be checked when new bearings are installed. When the bearing caps are off, the journals should be measured so that wear, out of roundness, or taper can be detected.

Bearing clearance can be checked either with feeler stock or Plastigage. Plastigage is a plastic material that is flattened by pressure. The amount it flattens indicates the amount of clearance.

Before checking bearing clearance with Plastigage, wipe the journal and the bearing clean of oil. Then place a strip of the Plastigage lengthwise in the center of the bearing cap (fig. 5-24). Install the cap next and tighten into place. When the cap is removed, the amount of flattening of the strip can be measured with a special scale (fig. 5-24). The flattened strip should not be removed from the cap or the journal to measure the width, but it should be measured in place, as shown in figure 5-24. Not only does the amount of flattening measure bearing clearance, but uneven flattening also indicates a tapered or worn crankshaft journal or bearing.

CAUTION: Do not turn the crankshaft with the Plastigage in place.

When feeler stock is used to check main bearing clearances, a piece of stock of the correct size and thickness should be placed in the bearing



75.327

Figure 5-24.—Checking bearing clearance with Plastigage.

cap after it is removed. The feeler stock should be coated lightly with oil. The bearing cap should then be replaced and tightened. Note the ease with which the crankshaft can be turned. As a word of caution, do not completely rotate the engine, which could damage the bearing. Turn it only about an inch in one direction or the other.

If the crankshaft is locked or drags noticeably after the bearing cap has been replaced and tightened, then the bearing clearance is less than the thickness of the feeler stock. If it does not tighten or drag, place an additional thickness of feeler stock on top of the first and again check the ease of crankshaft movement. Clearance normally should be about 0.002 inch. Be sure to check the engine manufacturer's shop manual for exact specifications.

CHECKING CRANKSHAFT END PLAY

Crankshaft end play will become excessive if the thrust bearings are worn, producing a sharp, irregular knock. If the wear is considerable, the knock will occur each time the clutch is engaged or released; this action causes sudden endwise movement of the crankshaft. Crankcase endplay should only be a few thousandths of an inch. To measure this end play, force the crankshaft endwise as far as possible by using a pry bar and then measure the clearance between the thrust bearing and the block with a feeler gage.

CYLINDER SERVICE

There are certain limits to which cylinders may become tapered or out of round before they require refinishing. If they are only slightly out of round or have only a slight taper (consult the manufacturer's manual for the maximum allowable out of round or taper), new standard rings can be installed. Where the walls have some taper, but not enough to warrant the extra expense of a rebore or hone job, special compression and oil-control rings should be used. Such rings are called SEVERE, or DRASTIC, because of their ability to withstand higher ring pressures and to work under more severe operating conditions or against greater taper than standard rings.

When cylinder wear goes beyond the point recommended in the engine manufacturer's specifications, even the SEVERE or DRASTIC rings cannot hold compression and control oil; loss of compression, high oil consumption, poor performance, and heavy carbon accumulations in the cylinder will result. In such cases, the only way to put the engine back into good operating condition is to refinish the cylinders and fit new pistons (or oversized pistons) and rings.

CHECKING CYLINDER WALLS

As a first step in checking cylinder walls, wipe them clean and examine them carefully for scored places and spotty wear (which shows up as dark, unpolished spots on the walls). Holding a light at the opposite end of the cylinder from the eye will help in the examination. If scores or spots are found, the cylinder walls should be refinished; even DRASTIC rings will not give satisfactory performance on such walls.

Next, measure the cylinders for taper and oval wear. This can be done with an inside micrometer, a telescopic gage and an outside micrometer, or by a special dial indicator as shown in figure 5-25. As the dial indicator is moved up and down in the cylinder and turned from one position to another, any irregularities will cause the needle to move. This will indicate how many thousandths of an inch the cylinder is out of round or tapered.

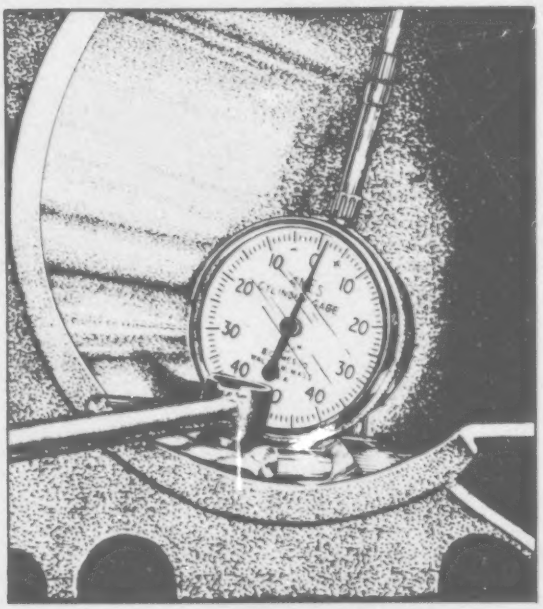
The permissible amount of taper or out of roundness in a cylinder varies somewhat with different engines. Engine manufacturers issue recommendations based on experience with their own engine. When the recommendations are exceeded, the cylinders have to be refinished.

REFINISHING CYLINDERS

There are two methods of refinishing cylinders: honing and boring. Cylinders are refinished by honing when wear is not too great. Otherwise they are bored with a machine and oversized pistons and rings installed. This machine consists of a boring bar and cutting tool that revolves. The procedures for mounting the boring bar, setting the cutting tool, and operating the boring machine will vary among different makes of equipment. Consult the manufacturer's operating manual for the procedures recommended.

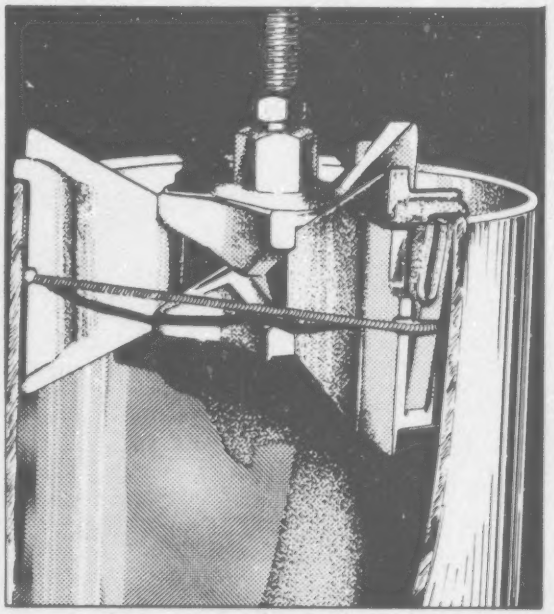
In honing, two sets of stones, coarse and fine, are generally used along with honing oil or cutting fluid. If a lot of material must be removed, start with the coarse stones. You must leave sufficient material, however, so that the rough honing marks can be removed with the fine stones. The final honed size must equal the size of the piston and rings to be installed.

Occasionally, during the final honing stage, clean the cylinder walls and check the piston size to guard against the removal of too much material or honing the cylinder oversize.



2.483

Figure 5-25.—Dial indicator for measuring cylinders.



2.484

Figure 5-26.—Ridge reamer.

Honing is sometimes used to "break" or "crack" the glaze on cylinder walls when new rings are installed. The idea behind this is to remove the smooth glaze that has formed on the cylinder walls, thus giving the new rings a chance to set quickly.

SERVICING PISTONS AND RINGS

When service is required on pistons and rings, they must first be removed from the engine. Where removal is to be from the top of the cylinder block, take the cylinder head off and examine the cylinder for wear. If the cylinder is worn, there will be a ridge at the upper limit of the top ring travel. Remove this ridge. If not removed, it will damage the piston and rings as they are forced out of the top of the cylinder.

To remove this ridge, use a reamer of the type shown in figure 5-26. Before placing the ridge reamer in the cylinder, be sure the piston has been placed at BDC (bottom dead center). Stuff rags into the cylinder to protect the piston

and piston rings from metal shavings during the reaming operation. Be sure to adjust the cutters to the correct depth of cut. Check the manufacturer's specifications for the recommended depth of cut as to the particular engine you are working on. After removing the recommended amount of metal, take the rags from the cylinder and wipe the cylinder wall clean. Repeat the reaming operation for other cylinders where necessary.

Before the connecting rods can be detached from the crankshaft, the oil pan must be removed. With the cylinder head and oil pan off, crank the engine so that the piston of the No. 1 cylinder is near BDC. Examine the piston rod and rod cap for identifying marks, and, if none can be seen, mark them with numbering dies to ensure replacing them in the same cylinders from which removed. Remove the rod nuts and cap with a wrench, and slide the rod and piston assembly up into the cylinder away from the crankshaft. After all piston and piston rod assemblies have been detached, they may be removed from the tops of the cylinders. It will be necessary to turn the crankshaft as you go from one cylinder to the next to detach the piston rods.

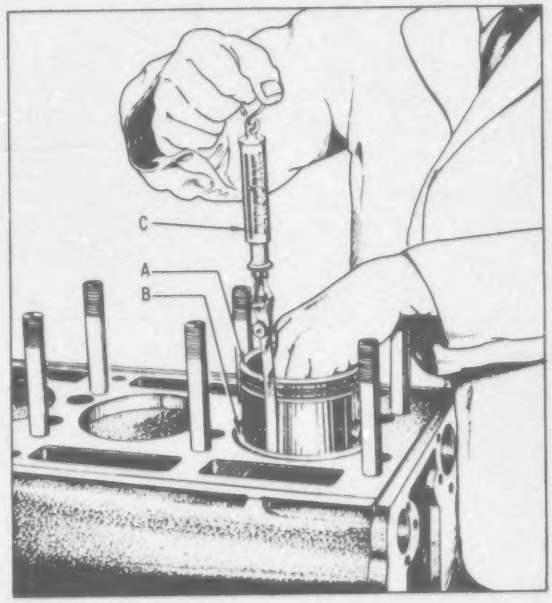
CLEANING PISTONS

After you have removed the piston rings, the piston should be cleaned inside and out. Examine the piston to determine whether it can be reinstalled in the engine. Even if the old piston is in good condition, a new piston may be required if the cylinder into which the piston fits is so worn that it must be bored to a larger diameter. Oversized pistons are installed in cylinders that are bored. When a piston is being cleaned, accumulations of carbon should be scraped from the head and from inside the piston. Do not scrape the sides or skirts of the piston, since this may scratch the finish and cause excessive cylinder wall wear. Use a ring-groove cleaner to remove built-up carbon from the ring grooves. When pulling this cleaner through the groove, remove only the carbon; do not remove any of the metal.

FITTING PISTON

After a piston has been cleaned, it should be measured with an outside micrometer. The measurements must be taken in various places to determine whether the piston is excessively worn or collapsed. Compare the measurements with those of the cylinder to determine if correct clearance exist. Consult the engine manufacturer's maintenance manual for details of measurements and allowable clearances, as well as for maximum allowable piston and cylinder wall taper. Most of the pistons you will encounter will be of the cam-ground type. This type is not round when cold, but slightly elliptical in shape. On this type of piston, taper is measured over the largest dimension which is perpendicular to the piston-pin holes.

The fit of the piston in the cylinder must be accurately determined. This fit can be measured with a piece of feeler stock of the proper thickness and a spring gage. The piston is inserted into the cylinder upside down with the feeler stock (lightly oiled) placed at right angles to, and 90 degrees from, the piston-pin holes. (See fig. 5-27.) The fit is measured at the point of greatest piston size. Check the amount of force required to pull out the feeler stock on the spring gage. If the feeler stock pulls out too easily, the fit is too loose. If it pulls out



A. Piston
B. Cylinder Sleeve
C. Thickness Ribbon and Spring Scale

2.485

Figure 5-27.—Checking piston fit in sleeve.

too hard, the fit is too tight. Check the manufacturer's maintenance manual for the correct amount of clearance.

FITTING PISTON PINS

If the piston pin bushings are worn, they should be reamed or honed oversize and oversize pins installed. The pins should also be replaced if they are worn, pitted, or otherwise defective.

Where the pin is of the type that floats, or turns in the piston pin bushing, the fit is correct if the pin will pass through with a light thumb pressure when the piston and the pin are at room temperature. Where the pin is of the type that does not turn in the piston pin bushing, the pin is forced in place under pressure. Check the manufacturer's maintenance manual for the correct pressure. If the pressure is too low, the fit is too loose and will result in noise. Excessive pressure indicates that the fit is too tight and may fracture the piston pin bosses.

FITTING PISTON RINGS

Piston rings must be fitted to their cylinder and to their grooves on the piston. First, check

75.54X

Figure 5-28.—Measuring ring gap clearance in cylinder bore.

75.318X

Figure 5-29.—Checking ring groove side clearance.

the gap or space between the ends of each ring. To do so, push a ring down into the cylinder with a piston, and measure the ring gap with a feeler gage (fig. 5-28). If the ring gap is too small, try a slightly smaller ring, which will have a larger gap. If the cylinder is worn tapered, the diameter at the lower limit of ring travel (in the assembled engine) will be smaller than the diameter at the top. In this type of cylinder the ring must be fitted to the diameter at the lower limit of ring travel. If fitted to the upper part of the cylinder, the ring gap will not be great enough as the ring is moved down to its lower limit of travel. This means that the ring ends will come together and the ring will be broken or the cylinder walls scuffed. In tapered cylinders make sure that the ring fits the cylinder at the point of minimum diameter, or at the lower limit of ring travel.

After the ring gap has been corrected, the ring should be installed in the proper ring groove on the piston and rolled around in the ring groove to be sure that the ring has a free fit around the entire circumference of the piston. An excessively tight fit means the ring groove is dirty and should be cleaned. After the rings are installed in the ring groove, test each ring for clearance by inserting a feeler gage between the ring and the side of the ring groove as shown in figure 5-29. Check the manufacturer's repair manual for proper clearance. If it is excessive, the piston should be replaced.

CHAPTER 6

AUTOMOTIVE ELECTRICAL SYSTEMS AND EQUIPMENT

In the early days of the automobile, only the automobile ignition system depended on electricity for operation. In today's automobile, the use of electricity has extended to include lighting and starting systems. Electricity is also used to operate many accessories, such as heating and ventilating fans, control units on automatic transmissions and overdrives, choke controls, turn signals, cigarette lighters, and air conditioners. Even heavy construction equipment has come to depend on electricity for operating starting systems and accessories. Storage batteries, generators, and regulators are required to provide an adequate source of electric power — both for construction and vehicular equipment.

Electrical accessories are no exception to the rule that the Construction Mechanic has responsibility for maintenance of parts and units attached to vehicles and equipment. Electrical repairs and adjustments, however, are specialized jobs that require the know-how of an expert — a person who has been specially trained for this type of work. Maintaining and repairing electrical systems and electrical accessories is a responsible job; every garage needs an automotive electrician. As a CMI or CMC, you will supervise this man as he performs his duties. In an emergency, you may have to perform these duties yourself. To assist you and your automotive electrician in maintaining and repairing electrical systems and accessories, the garage in which you work will probably have automotive electrical testing equipment. The mechanic who spends some time troubleshooting problems in regulators, generators, and batteries with the proper use of an ammeter or voltmeter will save his own time and yours and will reduce damage to equipment by hit-and-miss methods. Always follow the manufacturer's instructions for the instruments available to you. In addition to the basic automotive electrical systems and accessories you should be aware of the problems involved in shielding equipment; for example, providing safeguards against the interference of ignition and battery charging circuits with radio reception. One solution to this problem is a complex built-in interference reduction system. Original installation of shielding components is done either by the manufacturer or by an electronics technician trained for that type of work. The repair and maintenance is then the responsibility of the CM. Most installations are easily maintained and generally require no special handtools.

A Construction Mechanic First Class or Chief needs to be a jack-of-all-trades in that he must know how to repair nearly all kinds of automotive and construction equipment and accessories. In addition, he must be able to instruct less experienced men in a manner that is interesting and constructive.

All of the units in the automotive electrical system operate on a few fundamental electrical principles. An understanding of these principles leads to an easier understanding of these units and of how to service and repair them. Before reading this chapter, it would probably benefit you to review the related information in Basic Electricity, NAVPERS 10086-B, Basic Electronics, NAVPERS 10087-C, and Construction Mechanic 3 & 2, NAVPERS 10644-F.

In this chapter a more detailed explanation of some of the electrical units found on automotive equipment will be presented. Also, the methods of servicing and repairing these units will be explained.

A-C ELECTRICAL SYSTEMS

The output requirements of automotive electrical generators have increased considerably in recent years. This is because of the growing popularity of power consuming electrical accessories such as two-way radios and radiotelephones for communications, heavy-duty heaters, and air-conditioners.

To build a conventional d-c generator that would produce the required amount of electricity

at both a high and low speed range would mean an increase in size, thereby limiting application. An a-c generator (ALTERNATOR) has been developed that can be used in conjunction with a rectifier to produce enough power to fulfill almost any need over a speed range that varies from idle to top engine speed.

ALTERNATOR

Because of the small size of the alternator, it can be adapted to almost any application. It is mechanically constructed to withstand vibrations and top speeds that are encountered in normal service.

As can be readily understood from your studies in Construction Mechanic 3 & 2, the alternator and the conventional d-c generator operate on the same fundamental theory. The device for converting alternating current to direct current is the rectifier. The rectifier may be mounted internally within the alternator casing, or it may be mounted externally.

RECTIFIERS

Rectifiers of various types are manufactured for many uses. The two most common types of externally mounted rectifiers for automotive use are magnesium-copper sulfide rectifiers and selenium rectifiers.

A rectifier which is mounted internally within the generator is the silicon-diode rectifier, such as the one shown in figure 6-1.

The chemical composition of a diode is such that it will allow current to flow through itself in only one direction under normal conditions. The advantage of a silicon-diode rectifier is its small size, permitting it to be mounted internally within the casing of the alternator.

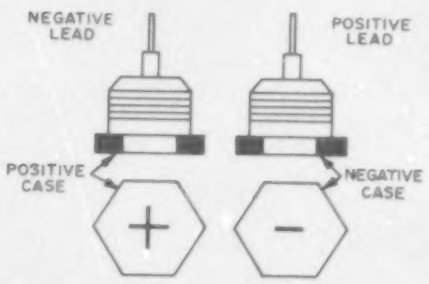


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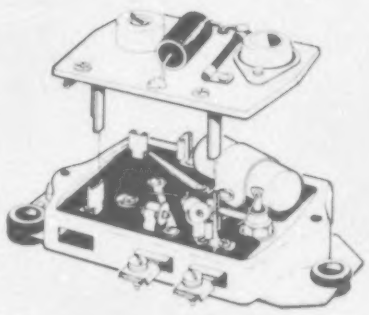
Figure 6-1. — Diodes.



2.306.2X

Figure 6-2. — Transistor regulator (Delco-Remy).

In the automotive type alternator using silicon-diode rectifiers, six rectifiers are used: three positive and three negative of the same construction.

The identification of silicon-diodes varies with the alternator model and manufacturer. Some types of diodes are plainly marked with a + or − sign to identify the polarity of the diode (fig. 6-1). Others are identified by black or red lettering. Always refer to the manufacturer's specifications when identifying diodes.

REGULATORS

As with d-c generators, some means must be provided to regulate the electrical output of an alternator. Normally, one of the following types of regulators would be used to accomplish this: the electromagnetic type, the carbon pile type, the transistor type or the transistorized type.

The electromagnetic and carbon pile type regulators are covered in Construction Mechanic 3 & 2. A short description of the transistor and transistorized type regulators follows.

The transistor regulator shown in figure 6-2 is a Delco-Remy model. It has only two terminals, contains no moving parts, and limits the generator voltage through the action of two transistors working together.

The transistor regulator performs one function only: to control the generator field current so as to limit the generator voltage to a preset value.

From the wiring diagram, shown in figure 6-3, it may be seen that the charging circuit consists of the a-c generator, regulator, battery, field

relay, junction block, wiring, and either an ammeter or indicator light.

The voltage setting may be adjusted externally by relocating a screw in the base of the regulator. The screw contacts the series of resistors and makes a connection to ground at the point of contact. Internal adjustment is accomplished by turning a slotted head screw on the potentiometer which varies the connection.

In a typical transistorized type of regulator, a single transistor works with a conventional voltage regulator unit containing a vibrating contact point to control the generator field current and thereby limit the generator voltage to a preset value.

The complete charging circuit, as illustrated in figure 6-4, containing a four-terminal regulator; consists of the generator, regulator, battery, ignition switch, ammeter, and wiring. The generator develops a-c voltage in the stator windings and is rectified to a d-c voltage that appears across the generator "BAT" terminal and the ground screw in the slip ringend frame.

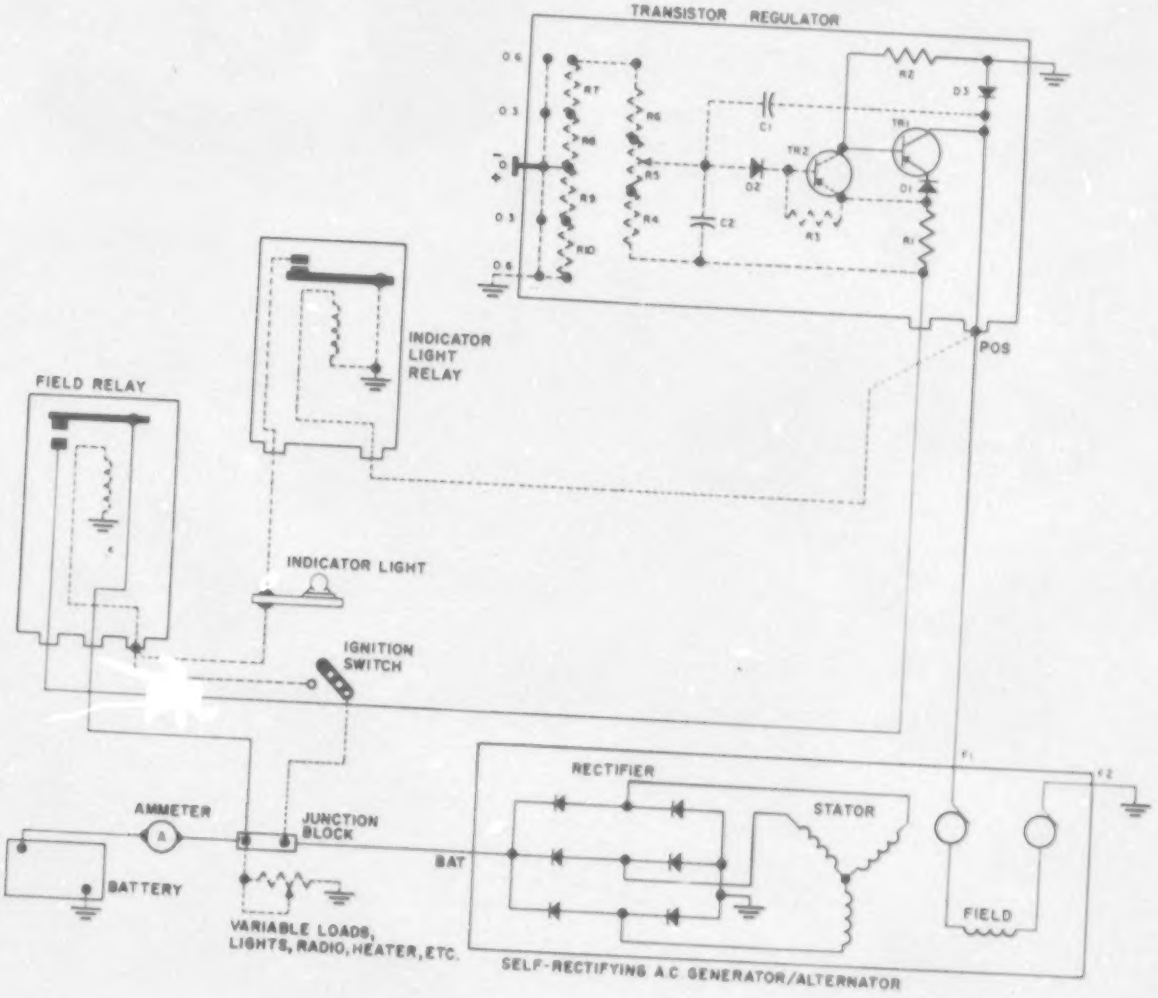
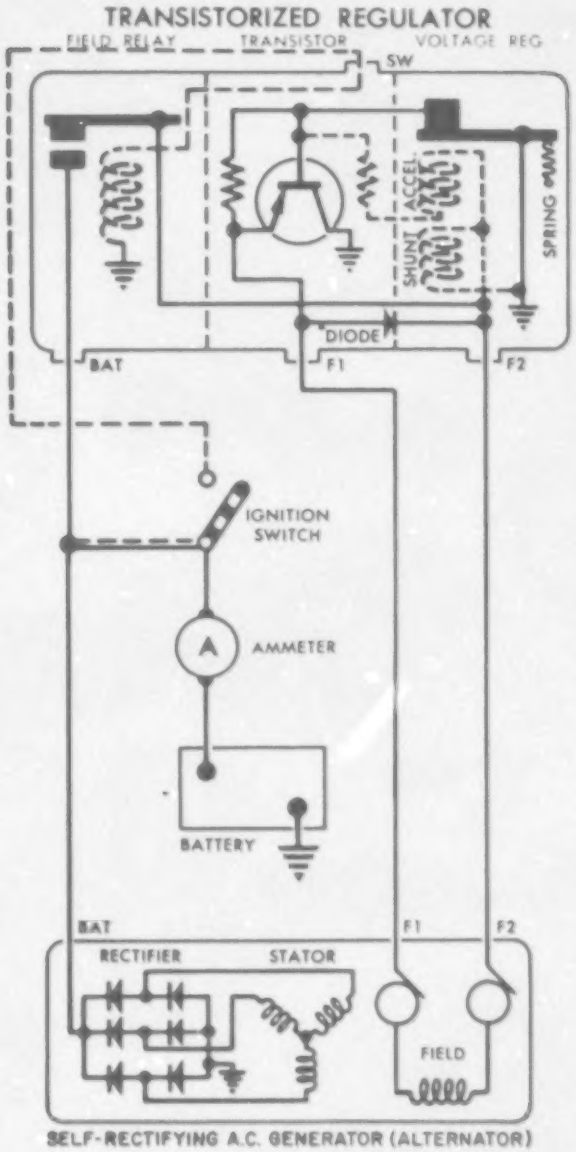


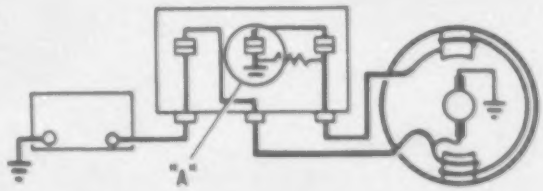
Figure 6-3.—Typical wiring diagram (transistor regulator). 2.308X

It is again stressed that, when performing services or repairs to regulators, you follow the manufacturer's service instructions for the specific make and model of regulator being serviced or repaired. Do not guess as to how to make repairs and adjustments to regulators.



2.307X

Figure 6-4.—Charging circuit (transistorized regulator).



2.510

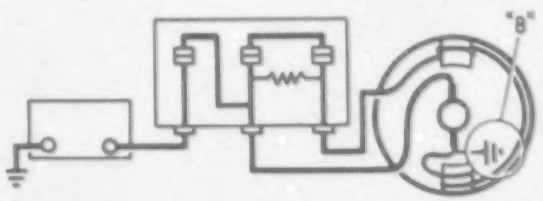
Figure 6-5.—"A" CIRCUIT.

TROUBLESHOOTING THE CHARGING SYSTEM

There are two types of vehicle charging systems in use today. One system is equipped with a d-c generator while the other uses an a-c generator or alternator. Both systems are tested in much the same manner.

Field circuits are commonly classified as "A" and "B" circuits. The "A" circuit, or externally grounded field as shown in figure 6-5 is connected to the armature terminal of the generator and is grounded outside the generator by the way of the regulator contacts. In the "B" circuit, illustrated in figure 6-6, the ground is reached internally and supply to the field is obtained via the armature circuit of the regulator. Most alternators and some brand d-c generators are "B" circuits.

A d-c generator depends upon its relatively permanent field pole piece magnetism for initial generator output. The polarity of this magnetic field determines the output polarity of the generator. A mismatched electric system will cause early component failure. A generator with no magnetic field can produce no output. Therefore, each time a generator is repaired, installed, inoperative for a period of time, or disconnected, it must be polarized. This is done by passing an



2.511

Figure 6-6.—"B" CIRCUIT.

electric current through the field winding in the proper direction BEFORE THE SYSTEM IS STARTED.

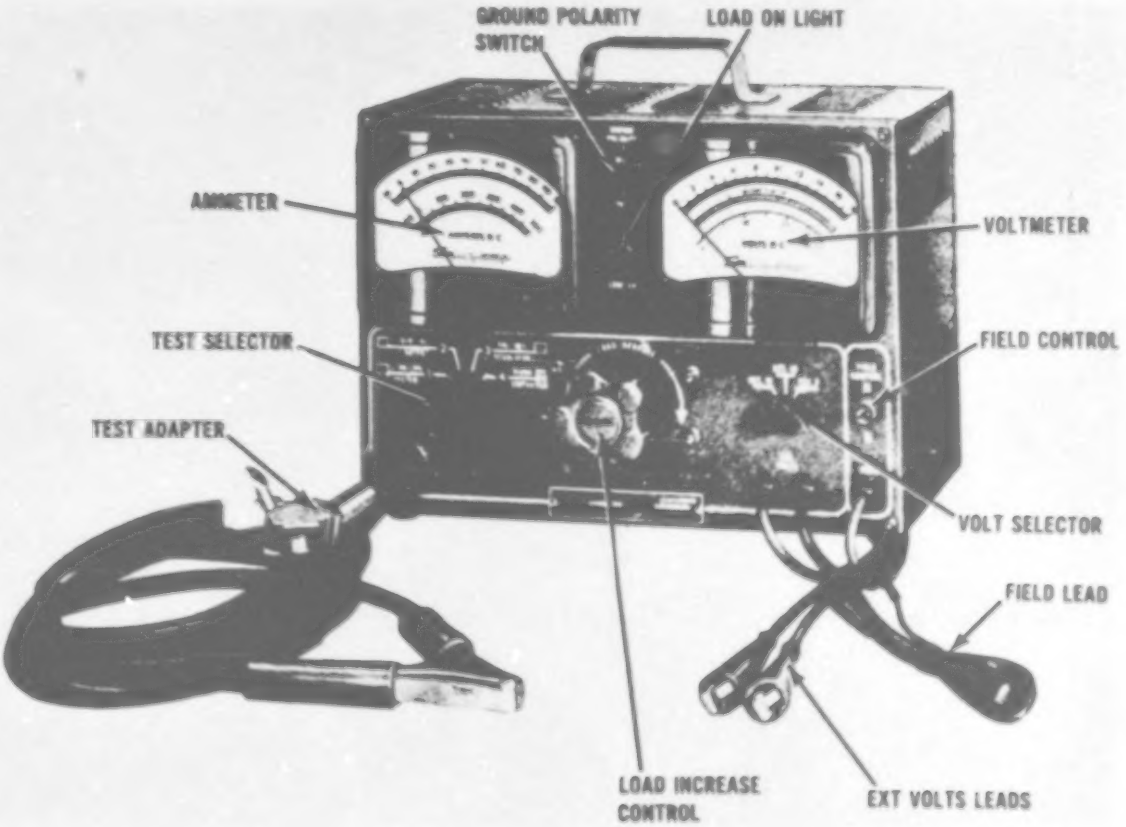
To polarize "A" CIRCUIT GENERATORS you must ground the field circuit at the generator FIELD terminal by momentarily applying battery voltage to the generator ARMATURE terminal, using a jumper at the regulator or generator. To polarize "B" CIRCUIT GENERATORS you disconnect the FIELD circuit lead at the regulator and momentarily touch this lead to the regulator BATTERY terminal.

REMEMBER. Alternators do not require polarization but some do require magnetizing.

When troubles in the vehicle's charging system are encountered, a volt-ampere tester (fig. 6-7) may be used to uncover these troubles.

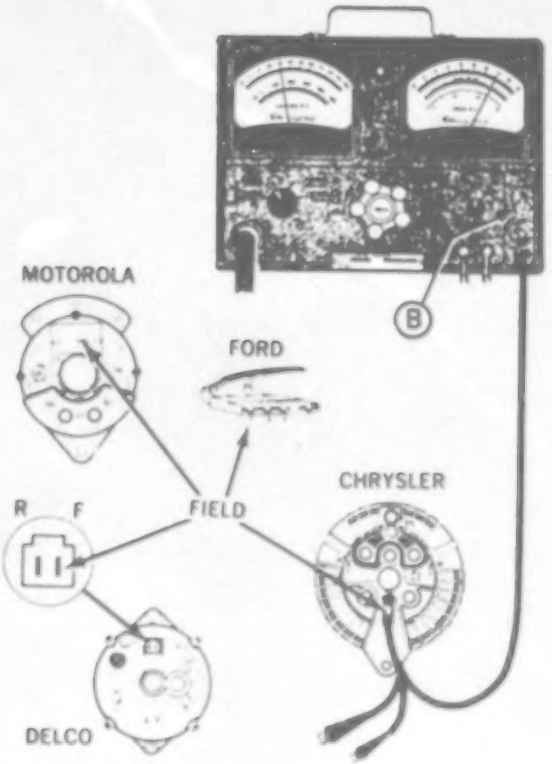
ALTERNATOR TEST

An alternator test is one of the first tests to be made with the volt-ampere tester. This test is made as follows: Disconnect the field wire at the alternator and connect the tester's field lead (fig. 6-8) to the alternator's field terminal. DO NOT allow the vehicle field wire to contact ground. Start the engine and hold the field control switch in "B" position (fig. 6-8). Then slowly increase engine speed while observing the blue AMMETER scale for the highest current indication. When the ammeter indication reads at the



2,320(2D)

Figure 6-7.—Volts-ampere tester.



2,512

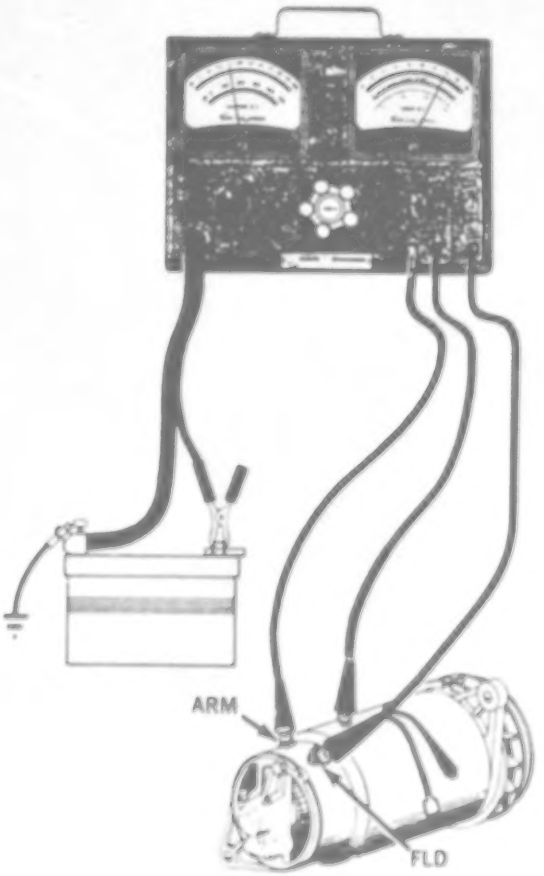
Figure 6-8. — Alternator output test.

normal output, the regulator must be replaced. When the ammeter indication reads at low or no output, the alternator must be repaired or replaced.

When a vehicle is equipped with an "A" type field circuit generator and the charging system fails, a generator test is made.

GENERATOR TEST

A generator test is made by disconnecting the field wire at the generator and connecting the tester's field lead (fig. 6-9) to the generator field terminal. DO NOT allow the vehicle or tester field wires to contact ground. For the "B" type field circuit generator, disconnect the field wire at the regulator and connect it to the armature terminal of the regulator. Now connect the red external volts lead (fig. 6-9) to the generator armature terminal and the black external volts lead to the generator frame or other good ground. (On positive ground systems reverse the external volts lead). Set the red volt selector to the external 18 position. Start the vehicle engine and slowly increase speed while observing the blue AMMETER scale for the highest ammeter reading. When the ammeter reads at the normal output, test the field lead of the wiring harness for an open circuit. If the field lead is okay, remove the regulator for testing, repair, or replacement as required. When the ammeter reads at low



2,513

Figure 6-9. — Generator output test.

output or normal voltage, the generator must be replaced or repaired. When the ammeter reads at no output or high voltage, and the circuit is not fused at the regulator, the regulator is removed for replacement or repair of its cutout relay. Also check the regulator ground. If the regulator is fused, bypass the fuse with a heavy jumper and observe the ammeter for output. An output at this point in your check indicates a blown fuse.

If the output of a d-c system exceeds the specification by 5 amperes or more, a defective current regulator or a shorted or grounded generator field is indicated, and an excessive output (d-c generator only) test should be made.

EXCESSIVE OUTPUT TEST

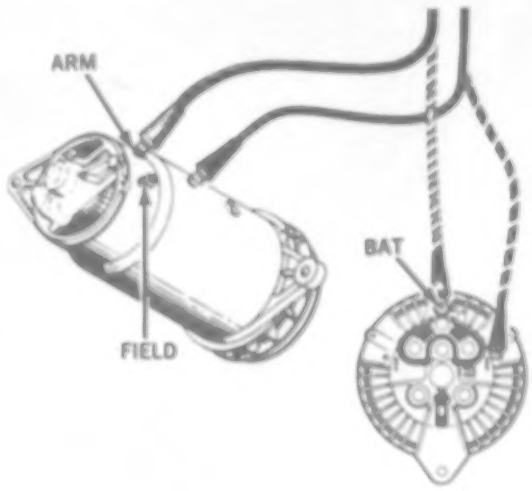
Set the black test selector knob to the voltage regulator position (fig. 6-9). Connect the black external volts lead to the generator armature terminal, and the red external volts lead to the generator frame or good ground. Start the engine and slowly increase speed while observing the green VOLTMETER scale for the highest voltmeter reading. If the voltmeter reads less than 16 volts (12-volt system) or 8 volts (6-volt system), the regulator's current limiter relay is causing of the high output. If the voltmeter reads more than 16 volts (12-volt system) or 8 volts (6-volt system), remove the FIELD wire at the regulator and observe the blue AMMETER scale. When the AMMETER reading shows no output, you have a defective regulator, which should be repaired or replaced. When the ammeter reading indicates a current output, remove the field wire at the generator and observe the ammeter. If the ammeter reading then shows no output, you have a shorted field wire. Replace the field wire connecting the generator to the regulator. On the other hand, if the ammeter shows current output, then the generator has a grounded field.

Another component of the vehicle charging system to be tested is the VOLTAGE REGULATOR. If the results of the test indicate voltage is too high or too low, a faulty regulator voltage limiter or a high series resistance in the charging system could be causing the trouble. When the voltage is erratic or unstable, it indicates poor circuit electrical connections, faulty regulator contacts (burned or oxidized), or damaged regulator resistors. In any case, you should proceed with a charging system circuit resistance test.

CHARGING SYSTEM CIRCUIT RESISTANCE TEST

A charging system circuit resistance test is made to determine the amount of voltage loss occurring between the output terminal of the generator or alternator and the insulated battery post, and between the generator or alternator housing and the ground battery post, respectively. Any voltage loss caused by high resistance in these circuits will reduce the overall charge rate and lead to eventual battery discharge. After setting the black test selector knob to the generator/alternator output position No. 2, set the blue load increase knob to the OFF position. Next, set the red volt selector knob to the External 18 position and then set the ground polarity switch to match battery ground.

The external volts lead is connected to the generator armature terminal when testing a generator, and to the battery terminal when testing an alternator. (See fig. 6-10.) Start the engine and adjust its speed to approximately 2,000 rpm. After the required speed is reached, adjust the blue load increase knob until the reading of the blue AMMETER scale indicates 20 amperes for d-c systems or 10 amperes for a-c systems.



2,514

Figure 6-10.—Circuit resistance test.

Also observe the reading on the green VOLTMETER scale and note (for future computation) this reading. Now, set the red volt selector knob to internal 18 position and observe the reading on the green VOLTMETER scale. Subtract this reading from the reading observed prior to setting the red volt selector knob to internal 18 position. The difference in the readings is the voltage drop caused by circuit resistance, which must be within the specifications for proper charging system operation as required by the vehicle manufacturer.

If a voltage loss exceeds the specified amount, an excessive resistance is present within the charging system; that is, within the wiring harness, connections, regulator, and vehicle ammeter (if used). The excessive resistance can take the form of LOOSE or CORRODED CONNECTIONS at the output terminal of the generator or alternator the armature terminal of the regulator or the back of the ammeter or battery terminal of the starter solenoid battery cable connections. Excessive resistance can also be present due to faulty wiring from generator to regulator to ammeter or ammeter to starter solenoid; burned or oxidized cutout relay contacts; or poor electrical connections between the generator or alternator and the engine. To isolate the point of excessive resistance, a charging system insulated circuit resistance test is made.

CHARGING SYSTEM INSULATED CIRCUIT RESISTANCE TEST

A charging system insulated circuit resistance test is made by setting the red volt selector knob to external 3 position. Observing polarity, connect the external volts lead to the generator armature terminal and to the battery terminal when testing an alternator. (See fig. 6-11.) Remember to reverse the external volts lead for positive ground systems. Start the engine and adjust its speed to approximately 2,000 rpm. After the required speed is reached, adjust the blue load increase knob until the blue AMMETER scale indicates a current of 20 amperes for d-c systems, or 10 amperes for a-c systems. Also observe the voltage reading on the (3 volt) VOLTMETER scale and compare with specifications for proper charging system operation as required by the vehicle manufacturer. If the reading is within specifications, you should proceed with a charging system ground circuit resistance test.

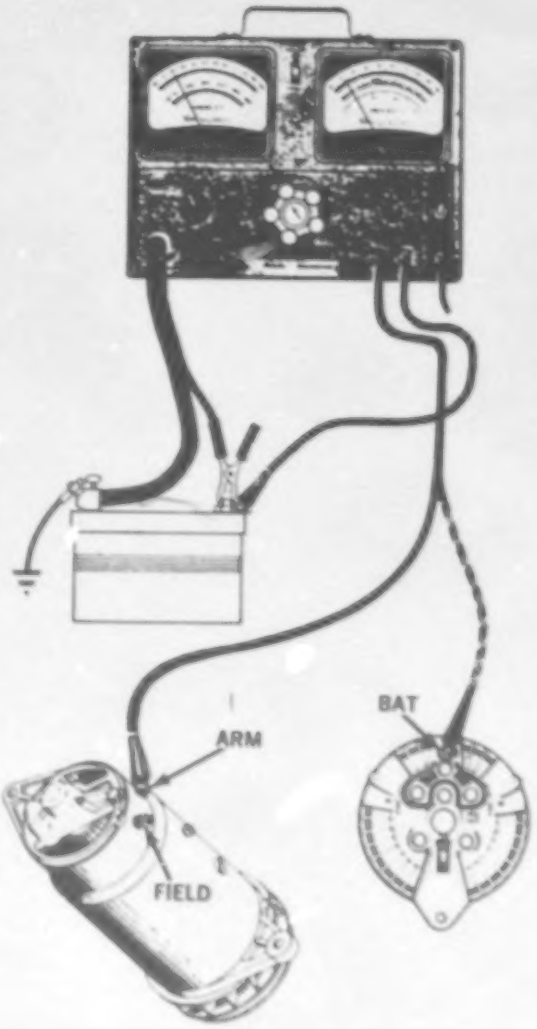


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Figure 6-11.—Insulated circuit resistance test.

CHARGING SYSTEM GROUND CIRCUIT RESISTANCE TEST

Observing polarity, connect the external volts lead to the generator or alternator ground terminal. (See fig. 6-12.) Remember to reverse the external volts lead for positive ground systems. Adjust the blue load increase knob until the blue

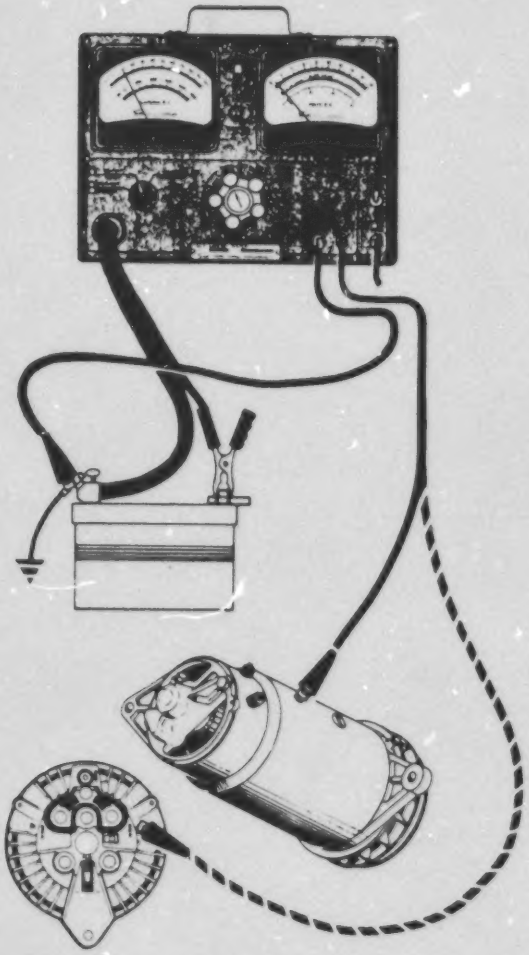

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Figure 6-12. — Ground circuit resistance test.

ammeter scale indicates a current of 20 amperes for d-c systems or 10 amperes for a-c systems. Also observe the voltage reading on the (3 volt) VOLTMETER scale and compare with specifications for proper charging system operating as required by the vehicle manufacturer. If the reading is within specifications, you should proceed with a regulator ground circuit resistance test.

REGULATOR GROUND CIRCUIT RESISTANCE TEST

Set the red volt selector knob to internal 1 position. Observing polarity, connect the external volts lead to the generator or alternator ground terminal and to the regulator ground terminal. (See fig. 6-13.) Remember to reverse the external volts lead for positive ground systems. Adjust the blue load increase knob until the blue AMMETER scale indicates a current of 10 amperes. Also observe the reading on the black (3 volt) VOLTMETER scale and compare with specifications. If the voltmeter reading exceeds 0.1 volt, excessive resistance is present in the ground circuit between the regulator and generator or

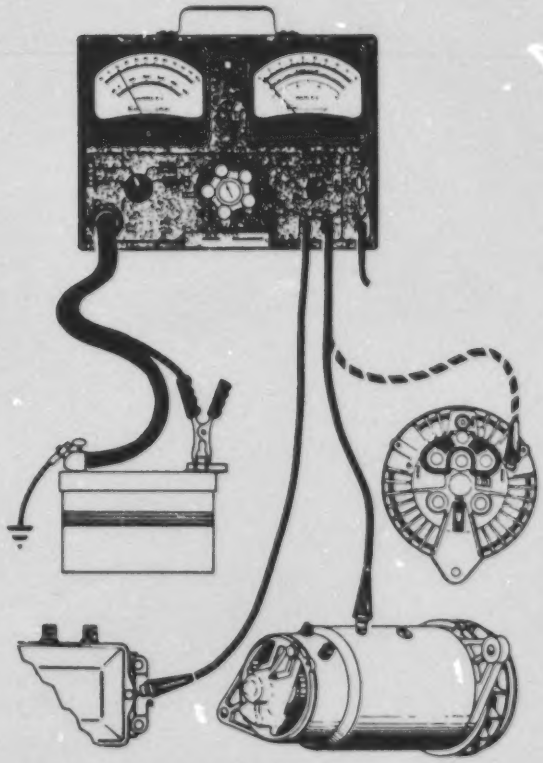

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Figure 6-13. — Regulator ground circuit resistance test.

alternator. Check the regulator ground system for loose mounting bolts or damaged ground strap.

DIODE-STATOR TEST

A diode-stator test is made to determine if any diodes or the stator are defective. It is possible for the alternator to indicate a satisfactory output with partially shorted stator windings or an open diode. Remember that this test is NOT TO BE PERFORMED UNLESS THE VOLTAGE REGULATOR TEST IS SATISFACTORY.

Set the black test selector knob to the diode-stator No. 4 position. Observe the red and green VOLTMETER scale. If the voltmeter pointer reads in the red area, then you would repair or replace the alternator in accordance with the manufacturer's instructions. If the voltmeter pointer reads in the green area, the diodes and stator are okay. You then proceed to the battery drain test.

BATTERY DRAIN TEST

This test is made to determine if there is a discharge current flowing when all accessories and lights are turned off. Any discharge at this time would indicate the presence of partially shorted wires, defective switches, or accessories. This condition of discharge leads to a frequently rundown battery and starting failure complaints. Set the black test selector knob to the generator/alternator output No. 2 position. Return the engine to idle and turn the vehicle ignition switch to OFF. Lights and accessories must be OFF and doors closed. Observe the blue AMMETER scale. If the ammeter scale reads zero, there are no short circuit paths for current, in which case the electrical system is okay and all tests are completed. If the ammeter scale reads other than zero, an electrical short circuit exists if all the vehicle circuits are turned OFF. The short circuit may be found by isolating each circuit, one at a time, until the ammeter reads zero. The last circuit isolated as the ammeter returned to zero is the defective one. Many circuits can be isolated by removing the circuit fuse from the fuse panel.

NOTE: At the conclusion of tests, return the engine to idle and stop it before disconnecting test leads. Reconnect the ground cable to the ground post of the battery and make sure all vehicle wires disconnected during the tests are once again securely and properly connected.

TROUBLESHOOTING THE STARTER SYSTEM

To determine whether a battery is fit for service, starting system tests are performed with a battery starter tester, model BST-11, as illustrated in figure 6-14. This tester, made by Sun Electric Corporation is especially designed to test batteries and starting systems of vehicles using 6-, 12-, 24-, or 32-volt systems.

CRANKING VOLTAGE TEST

A cranking voltage test is made by connecting the tester's voltmeter leads as shown in figure 6-15 for a 6-, 12-, or 24-volt series system, observing the polarity as you make the connections. Turn the voltmeter selector switch (fig. 6-15) to 8 volts for a 6-volt system, 16 volts for a 12-volt system, or 40 volts for a 24-volt system. When a vehicle is equipped with a 24-volt series parallel system, the voltmeter leads are attached to the two terminals on the starting motor. Before cranking the engine with the ignition switch ON, connect a jumper from the secondary terminal of the coil to ground to prevent the engine from starting while testing. While cranking, observe both the voltmeter reading and cranking speed. The starter should crank the engine evenly, and at a good rate of speed, with a voltmeter reading as follows (unless otherwise specified):

4.8 volts or more for a 6-volt system.
9.6 volts or more for a 12-volt system.
18 volts or more for a 24-volt system.

When the cranking voltage and cranking speed are good, it is reasonably safe to assume that the starting motor and starting circuits are in order. If the cranking voltage is lower than specified, test the battery capacity, starter circuits, and starter cranking current. However, if the cranking voltage is high but the starter action is sluggish, check for starting circuit resistance as outlined in the circuit resistance tests given later in this chapter.

Excessive starting motor current is an indication of trouble in the starting circuit, provided the engine cranking load is normal. However, increased current must be considered normal on new or newly overhauled engines or in any case where the cranking load is above normal.

To check an excessive starting motor current a starting motor current draw test of the 6-, 12-, or 24-volt series system is performed.

STARTING MOTOR CURRENT DRAW TEST

Connect the tester's VOLTMETER leads as shown in figure 6-16. Turn the battery starter tester control knob to the OFF position. Then turn the voltmeter selector switch (fig. 6-16) to 8 volts for a 6-volt system or 16 volts for a 12-volt system. When a vehicle is equipped with a 24-volt series system, the voltmeter selector switch is turned to 16 volts if 12-volt batteries are used or to 8 volts if 6-volt batteries are used. On a 24-volt series system, connect the voltmeter leads across one 6- or 12-volt battery ONLY.

Before cranking the engine with the ignition switch ON, connect a jumper from the secondary terminal of the coil to ground to prevent the engine from starting while testing. While cranking, note the exact reading on the voltmeter. After cranking, turn the control knob of the battery tester clockwise until the voltmeter again reads exactly as it did during cranking. The test AMMETER should indicate the starting motor current within the normal range of the vehicle being tested, as determined from the manufacturer's specifications. However, if the test indicates normal starter current, but low cranking speed, check resistance in the starting circuit. If high starter current is encountered during the test, starting circuit trouble is indicated. In the case of low starter current—accompanied by low cranking speed—or complete failure of the engine to crank, resistance within the starting circuit wiring or starting motor is indicated. These resistance problems should be checked out by following test procedures outlined in the circuit resistance tests described in following sections.

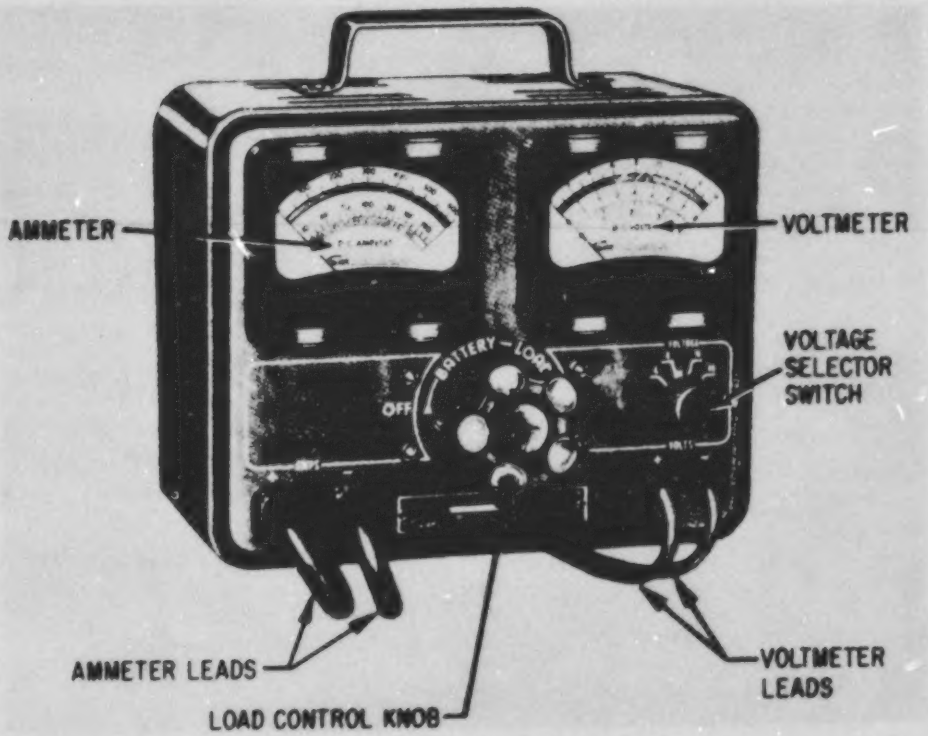

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Figure 6-14.—Battery starter tester.

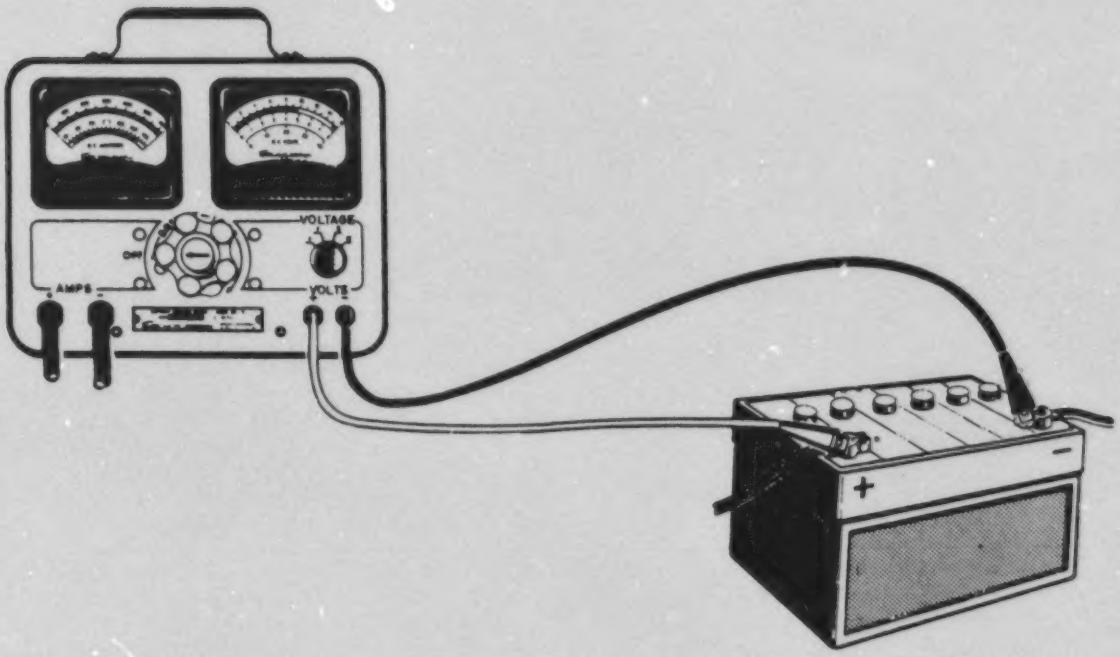

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Figure 6-15.—Cranking voltage test.

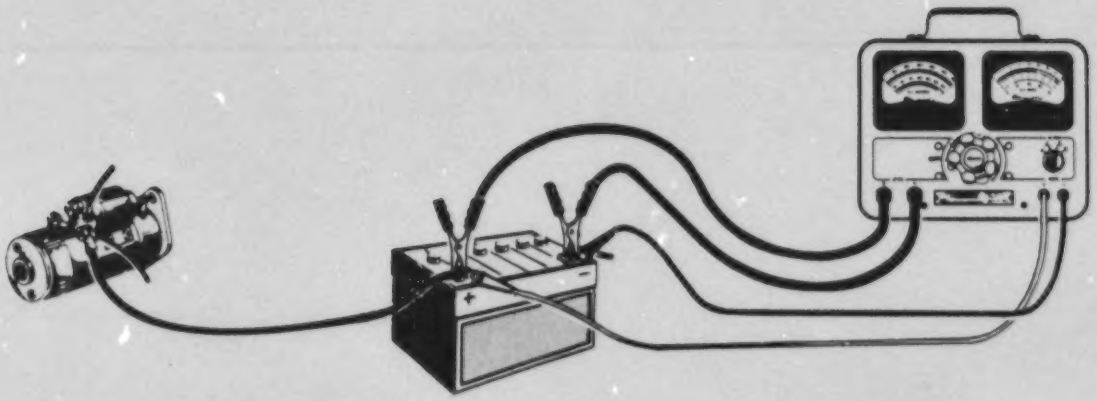

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Figure 6-16.—Starting motor current draw test.

STARTER INSULATED CIRCUIT RESISTANCE TEST (CABLES AND SWITCHES)

The starter insulated circuit resistance test of a 6-, 12-, or 24-volt series systems is performed as follows. Connect the tester's VOLTMETER leads as shown in view A, B, and C of figure 6-17 for the type of current being tested, observing the polarity as you make the connections. The voltmeter will read off-scale to the right until the engine is cranked. The voltmeter lead clips must be in good contact with the battery posts and the starter terminal. Now, turn the voltmeter selector switch to the No. 4 VOLT position. Before cranking the engine with the ignition switch ON, connect a jumper from the secondary terminal of the coil to ground to prevent the engine from starting while testing. While cranking the engine, observe the voltmeter reading which should be within the manufacturer's specifications. Unless otherwise specified by the manufacturer, the voltage loss in each of the circuits shown in views A, B, and C of figure 6-17 should not exceed the values given.

When you are testing a 6-volt system, the completed circuit shown in view A of figure 6-17 allows a .2 volt loss, that of view B of figure 6-17 allows a .3 volt loss. When you are testing a 12-volt system, the completed circuit shown in view A of figure 6-17 allows a .4 volt loss, that of view B a .3 volt loss, and that of view C, a .1 volt loss. If you are testing a 24- or 32-volt system, refer to the manufacturer's specifications. If the voltmeter reading is more than specified for the type of system being tested, high resistance is indicated in the cables, switches, or connections. A repeat test with the voltmeter connected to each cable, switch, and connection is required, and the maximum readings taken across the various parts of the circuit should not exceed the values listed below.

	6-Volt System	12-Volt System
Each cable	.1 volt	.2 volt
Each switch	.1 volt	.1 volt
Each connection	.0 volt	.0 volt

STARTER GROUND CIRCUIT RESISTANCE TEST

Excessive resistance in the ground circuit of the starting system can cause sluggish cranking action or failure to crank, and can also seriously interfere with the operation of the other electrical circuits using the same ground.

The starter ground circuit resistance test of a 6-, 12-, or 24-volt series system is performed as follows: Connect the tester's VOLTMETER leads as shown in figure 6-18, observing the polarity as you make the connections. Be sure the voltmeter lead clip at the battery contacts the battery post and not the battery cable clamp. Now, turn the voltmeter selector switch to the No. 4 VOLT position. Before cranking the engine with the ignition switch ON, connect a jumper lead from the secondary terminal of the coil to ground in order to prevent the engine from starting while testing. While cranking the engine, observe the voltmeter reading. This reading, unless otherwise specified by the manufacturer's specifications, should not exceed a .2 volt loss. If the reading is more than the .2 volt loss, this usually indicates a loose, dirty or corroded connection, or that the ground cables are too small to carry the current. To locate the point of excessive resistance, apply the voltmeter leads across each connection and cable, in turn, and take the readings with the starting motor in operation. These readings should not exceed .. volt loss on short ground cables and should be zero across each connection. Long ground cables may have slightly more than a .2 volt loss.

SOLENOID SWITCH CIRCUIT RESISTANCE TEST

High resistance in the solenoid switch circuit will reduce the current flow through the solenoid windings and cause the solenoid to function improperly or not at all. Improper action of the solenoid switch will, in most cases, result in burning of the main switch contacts, thus reducing current flow in the starter motor circuit.

The solenoid switch circuit resistance test of a 6-, 12-, or 24-volt series system is performed as follows: Connect the tester's VOLTMETER leads as shown in figure 6-19, observing the polarity as you make the connections. Be sure the voltmeter lead clip at the solenoid contacts the switch terminal, not the solenoid wire end. Now, turn the voltmeter selector switch to the No. 4 VOLT position. Before cranking the engine with the ignition switch ON, connect a jumper lead from the secondary terminal of the coil to ground to prevent the engine from starting while testing. While cranking the engine, observe the voltmeter reading. This reading, unless otherwise specified by the manufacturer's specifications, should not exceed a .5 volt loss. If the

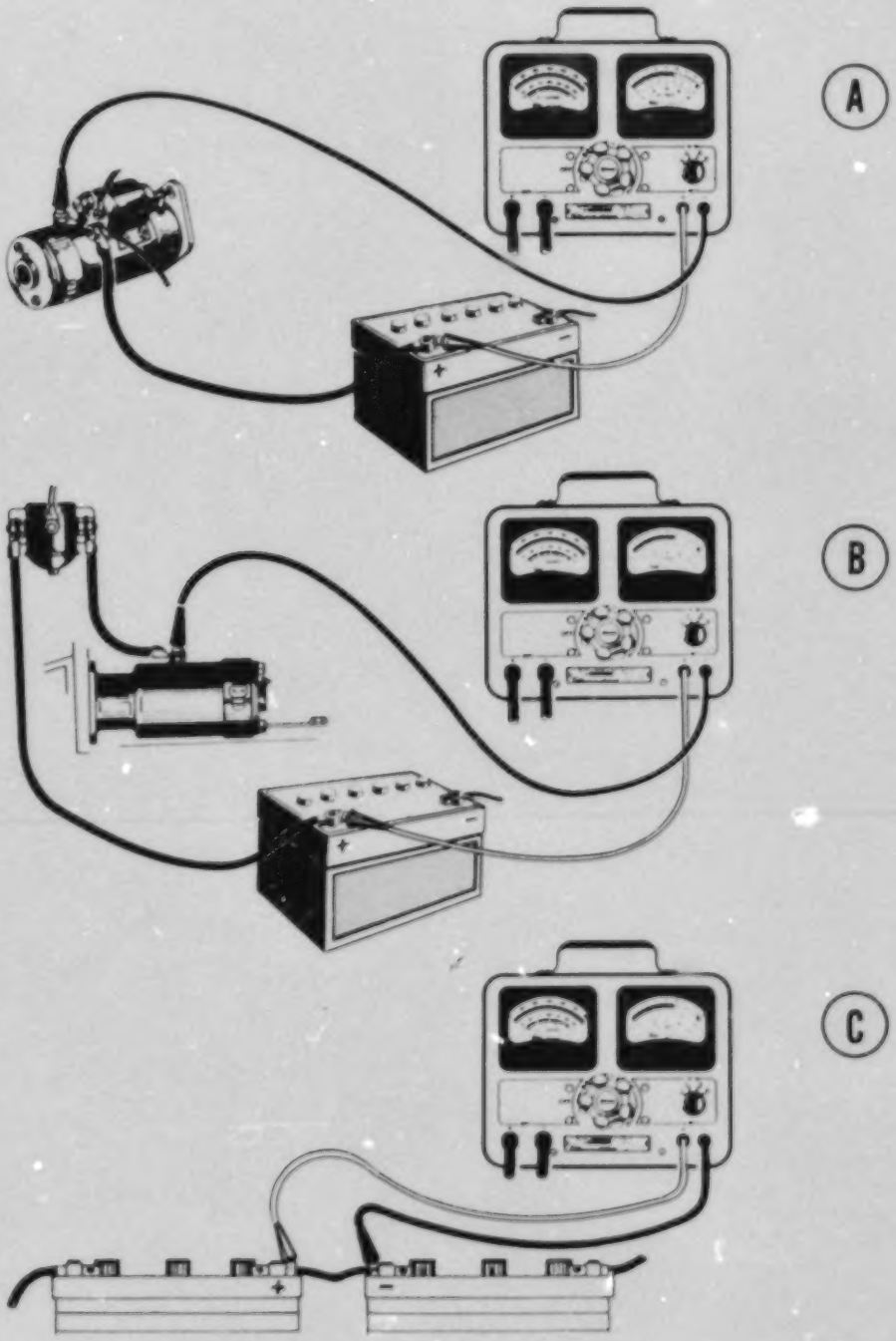

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Figure 6-17.—Starter insulated circuit resistance test.

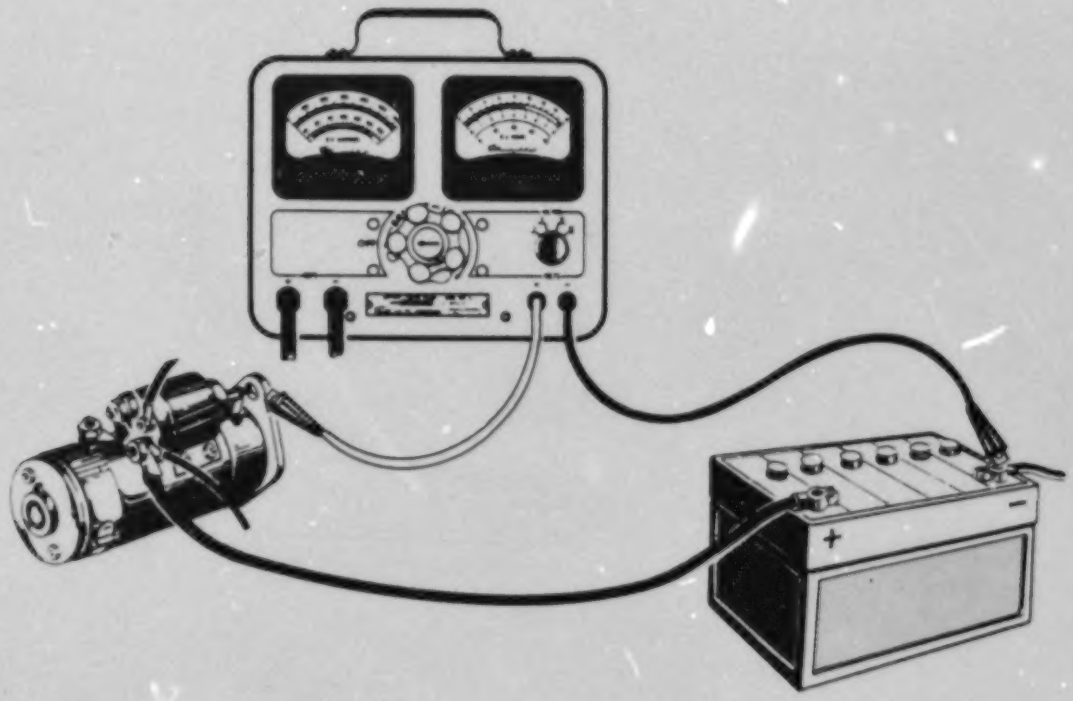

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Figure 6-18.—Starter ground circuit resistance test.

reading is more than a .5 volt loss, it is usually an indication of excessive resistance. However, on certain vehicles, experience may show that a slightly higher voltage loss is normal. To isolate the point of high resistance, apply the voltmeter leads across each part of the circuit in turn, taking readings with the starting motor in operation. When a reading of more than a .1 volt loss appears across any one wire or switch, it is usually an indication of trouble. If high readings are obtained across the neutral safety switch used on automatic transmission equipped vehicles, check the adjustments of the switch as outlined in the manufacturer's manual. Make sure all vehicle wires disconnected during the tests are reconnected securely and properly at the conclusion of the tests.

IGNITION SYSTEMS

The treatment of ignition systems given in Construction Mechanic 3 & 2, NAVPERS 10644-F, deals mainly with the operating principles of a conventional automotive ignition system. The treatment here continues with the basic types of transistor ignition systems (breaker-point and magnetic-pulse), the capacitor discharge ignition system, the Chrysler electronic ignition system; and the Delco-Remy unitized ignition system. This chapter closes with techniques for troubleshooting ignition systems.

TRANSISTOR IGNITION SYSTEM (BREAKER-POINT TYPE)

The breaker point type of transistor ignition system was developed to replace the standard or conventional ignition system of the modern high compression automotive engine. To obtain the maximum power and speed that this engine can produce, it is necessary to install an ignition system which outperforms the conventional one. At high speeds, the breaker points of a conventional ignition system cannot handle the increased current flowing across them without pitting too much. Also, the dwell angle of the

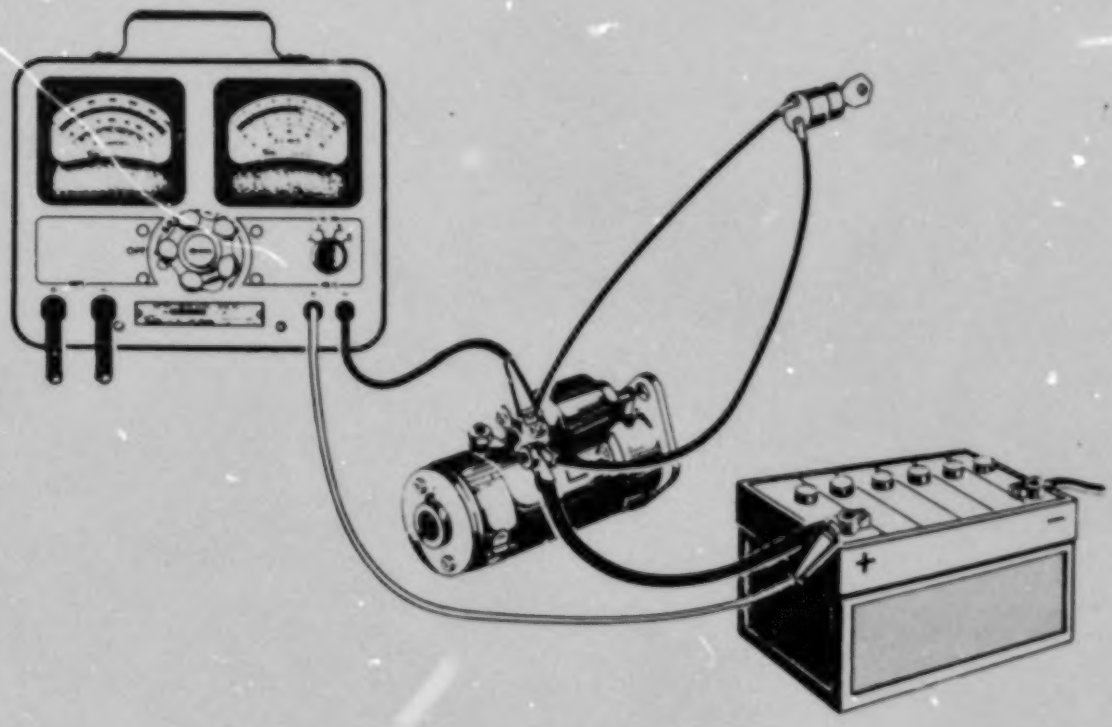

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Figure 6-19.—Solenoid switch circuit resistance test.

breaker points is too small for complete saturation of the ignition coil. The transistorized ignition system takes care of both drawbacks.

By comparing figure 6-20 and 6-21, you can see the ways in which the transistor ignition system differs from the conventional. Connecting the breaker points to the transistor as shown in figure 6-21 nearly eliminates arcing across them since the current flow is small (about 1/2 ampere). However, the current flow in the primary windings of the coil is about 6 amperes. This amount is enough to completely saturate the coil at high engine speeds, and results in a bigger output to the secondary circuit. At high engine speeds, therefore, the transistor ignition system is superior to the conventional system because there is (1) less arcing across the breaker points and (2) higher and steadier voltage in the secondary circuit.

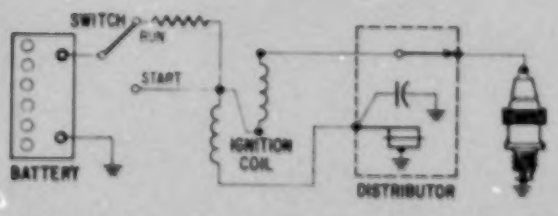

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Figure 6-20.—Conventional ignition system.

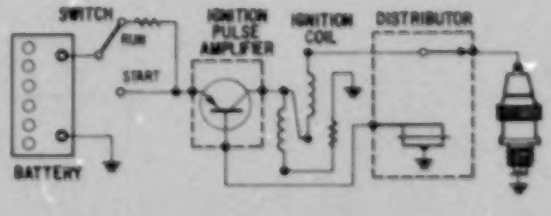

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Figure 6-21.—Transistor ignition system (breaker-point type).

TRANSISTOR IGNITION SYSTEM (MAGNETIC PULSE-TYPE)

The drawbacks of a conventional ignition system operating at high engine speeds can also be overcome with the magnetic pulse type of transistor ignition system (figure 6-22). Notice that a magnetic pulse distributor, which resembles a conventional distributor, is used instead of a breaker point type of distributor. An iron timer core in this distributor replaces the standard breaker cam. The timer core has equally spaced projections (one for each cylinder of the engine), and rotates inside a magnetic pickup assembly. This pickup assembly replaces the breaker plate assembly of the conventional distributor. Since there are no breaker points or condenser, there can be no arcing across them. This overcomes one of the drawbacks already mentioned. The other drawback is overcome by controlling the amount of current that flows through the primary windings of the ignition coil and to ground. Transistors in the ignition pulse amplifier do the controlling. Another feature of this transistor ignition system is its coil, which has fewer and heavier primary windings and a higher turns ratio of primary to secondary windings than the conventional coil does. Controlling the current flow and using a special coil produce the desired voltage in the secondary circuit at high engine speeds.

CAPACITOR DISCHARGE IGNITION SYSTEM

The capacitor discharge (CD) ignition system is also superior to the conventional ignition system. Like the magnetic pulse transistor ignition system, the CD system has a special ignition coil, a transistorized pulse amplifier, and a magnetic pulse (breakerless) distributor. Unlike the magnetic pulse transistor ignition system, the CD system has a high voltage condenser connected across the primary windings of the coil. The input to the coil is constant and assures complete saturation of the coil, which results in the desired secondary voltage output at high engine speeds. You can identify the CD ignition system by its red distributor cap and coil.

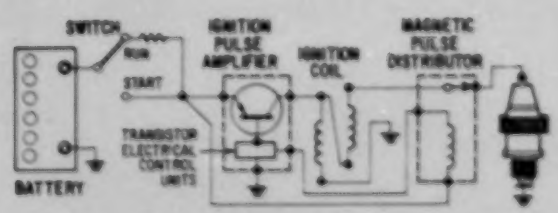

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Figure 6-22.—Magnetic pulse type transistor ignition system.

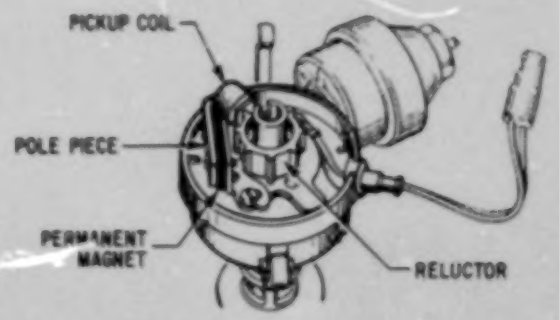

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Figure 6-23.—Electronic ignition distributor components.

ELECTRONIC IGNITION SYSTEM (CHRYSLER)

Like the magnetic pulse type of transistor ignition system, Chrysler's electronic ignition system is breakerless, that is, there are no breaker points or condenser. See figure 6-23. The distributor plate contains a pole piece, a permanent magnet, a pickup coil instead of the breaker points and condenser. The reluctor replaces the distributor cam. A ballast resistor, an electronic control unit, and a standard ignition coil also belong to this ignition system.

UNITIZED IGNITION SYSTEM (DELCO-REMY)

The unitized ignition system by Delco-Remy is another breakerless ignition system. It is called unitized because the entire system is built into one unit, the distributor. This distributor contains the ignition coil, the secondary wiring harness and cap, shell, rotor, vacuum advance unit, pickup coil, timer core (which replaces the cam), and electronic module. The distributor operates on an electronically amplified pulse. Vacuum spark advance is applied in the usual way; so is the mechanical spark advance. The moving parts of this system induce a voltage which signals the electronic module to interrupt

the primary circuit. The desired voltage is then induced in the secondary windings of the ignition coil, and directed to the proper spark plug by the rotor and the secondary wiring harness and cap.

TROUBLESHOOTING THE CONVENTIONAL/ COIL IGNITION SYSTEM

In troubleshooting a conventional ignition system, you conduct separate tests on the primary circuit (low voltage) and the secondary circuit (high voltage). The primary circuit carries current at battery voltage, whereas the secondary voltage could be as much as 30,000 volts.

Primary Circuit Tests

Using a simple voltmeter, you can check a 12-volt primary circuit as follows:

1. Hook up the voltmeter between the switch side of the ignition coil and a good ground. The engine must be at operating temperature, but stopped, and the distributor side of the coil grounded with a jumper wire. See figure 6-24.

2. With ignition switch on, jiggle it and watch the voltmeter. The switch is defective if the meter needle fluctuates. The voltmeter should read a steady 5.5 to 7 volts.

3. Crank the engine and watch the voltmeter. It should read at least 9 volts while the engine is being cranked.

4. Remove the jumper wire from the coil, then start the engine. The meter reading should be 9 to 11.5 volts while the engine is running.

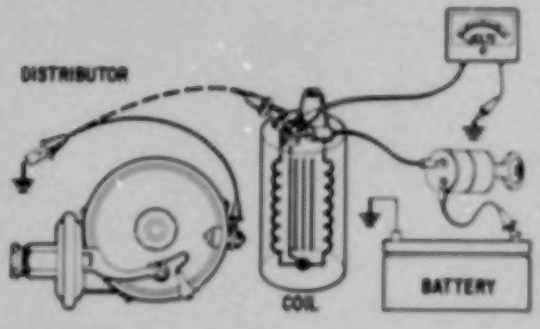

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Figure 6-24.—Testing ignition primary circuit.

5. Stop the engine by turning off the ignition switch. Hook up the voltmeter between the distributor side of the coil and ground. Remove the high tension wire from the coil and ground it.

6. Close the ignition switch and slowly open and close the breaker points by bumping the engine. When the points make and break, the voltmeter should read between 4 and 6 volts. Normally, with the engine stopped and points open, the reading will be 12 volts; with points closed, the reading will be near zero volts. If while the engine is cranked, the voltmeter reading stays at zero or near zero, the following four checks will have to be made to locate the source of trouble.

7. Check for current flow at the distributor. Disconnect the distributor primary wire from the top of the coil. Take a voltmeter reading from the distributor terminal of the coil. Current should flow through the circuit.

8. Check opening and closing of the breaker points. If not adjusted properly, they may not open and close. Also look for a mechanical failure of the points or cam.

9. Check grounding of the movable breaker point, the stud at the primary distributor wire terminal, or the wire of the condenser (pigtail). None of these should be grounded.

10. Check the condition of the condenser with an ohmmeter. Connect one test lead of the meter to the body of the condenser, the other test lead to the pigtail. To avoid damage to the meter, discharge the condenser before connecting the test leads. The condenser is shorted if the meter gives a reading, no matter how small.

Secondary Circuit Tests

The high voltage in the secondary circuit is produced by the ignition coil. Current flows out of the coil at the secondary terminal through a cable to the distributor cap and rotor. The rotor distributes the current through the cap and cables to the spark plugs, and then to ground. The checkpoints for the secondary circuit include the secondary terminal of the coil, the coil-to-distributor cap cable, the distributor cap, rotor, spark plug cables, and spark plugs.

The secondary circuit can be checked as follows:

1. Pull the coil high voltage cable from the distributor cap and hold the loose end of the cable about 1/4 inch from a good grounding point on the engine block.

2. Crank the engine and look for a spark to bridge the gap between the loose end of the cable and the grounding point. If you see a hot or fat spark, proceed to the next step since the coil is functioning normally. If you see a weak spark or no spark at all, the trouble sources are in the primary circuit, the coil, and the coil-to-distributor cable.

3. Remove the spark plug cables from the spark plugs and lift off the distributor cap. Connect one ohmmeter test lead to a spark plug cable connector and the other test lead to the terminal inside the distributor cap for the spark plug cable. Measure the resistance of the other spark plug cables in turn. Cable resistance should not exceed manufacturer's recommendations. Excessive resistance can result from cable damage, defective spark plug connector, corroded distributor cap tower, or unseated cable in the tower.

4. Inspect the distributor cap, inside and out, for carbon tracking and cracks; also inspect for a worn center contact button or burned spark plug cable contacts.

5. Remove the rotor and inspect it. Look for high resistance carbon, a burned tip, or a grounded rotor.

6. Remove all spark plugs from the engine and inspect each one. Look for fouled plug tips, gaps that are too wide or bridged, chipped insulators, and other conditions that can cause high resistance at the electrodes.

Coil Resistance Tests

Using a simple ohmmeter, you can check the resistance of the ignition coil. Its primary circuit and secondary circuit are tested separately. To check the primary side, connect the ohmmeter leads across the primary terminals of the coil. Use the low ohms scale of the meter. The resistance should be about 1 ohm for coils requiring external ballast resistors, about 4 ohms for coils not requiring the ballast resistors. In checking the secondary side, switch to the high scale of the ohmmeter. Connect one ohmmeter lead to the distributor cap end of the coil secondary wire, the other lead to the distributor terminal of the coil. The condition of the coil is satisfactory if the meter reading is between 4,000 and 8,000 ohms, although the resistance of some special coils may be as high as 13,000 ohms. Should the reading be a lot less than 4,000 ohms, the secondary turns of the coil are probably shorted. A reading of 40,000 ohms or more indicates an open secondary, a bad connection at the coil terminal, or a high resistance in the cable.

TROUBLESHOOTING A TRANSISTOR IGNITION SYSTEM

The preceding techniques for troubleshooting a conventional battery/coil ignition system also apply, for the most part, to troubleshooting the basic types of transistorized ignition systems—breaker point type and breakerless. Special techniques, however, are used in checking the electronic components of a transistorized ignition system. Since these components are easily damaged by heat, shock, or reverse polarity, you must be extra careful in checking them. The following steps form the procedure for trouble-checking the breakerless system:

1. Pull the high voltage cable from the distributor cap and hold the loose end of the cable about 1/4 inch from a good grounding point on the engine block.

2. With ignition switch on, crank the engine and look for a spark to bridge the gap between the loose end of the cable and the grounding point. If you see a hot or fat spark, reconnect the high voltage cable to the distributor and proceed to step 3. If you don't see a spark or see a weak spark, proceed to step 4.

3. Pull the cable from a spark plug and hold the loose end of the cable about 1/4 inch from the spark plug terminal. With ignition switch on, crank the engine and look for a spark to bridge the gap between the loose end of the spark plug cable and the sparkplug terminal. A good spark here indicates a normal operating condition.

4. With weak spark or no spark, test the coil. Since a special coil is used in this ignition system, you cannot test it with a conventional coil tester. Use an ohmmeter to check the continuity of the coil's primary and secondary windings. With leads disconnected from the coil, connect the ohmmeter across the primary terminals. If the meter reading is infinite, the primary winding is open. The secondary winding is checked by connecting the ohmmeter to the coil case and to the high voltage center tower. Again, an infinite reading indicates an open winding. Be sure to use the middle or high resistance range of the ohmmeter when you check the continuity of the secondary winding.

5. Check operation of the ignition pulse amplifier. To do so, detach the positive and negative

leads from the coil and connect them in series to a 12-volt, 2 candlepower bulb.

6. Crank the engine and observe the bulb. If it flickers on and off, the amplifier is operating properly. If the bulb does not flicker on and off, check the distributor.

7. Connect a vacuum source to the distributor and an ohmmeter to the two terminals on the distributor connector. Open the vacuum source to the distributor and observe the ohmmeter throughout the range of the vacuum source. A reading less than 550 ohms or more than 750 ohms indicates a defective pickup coil in the distributor.

8. Remove one ohmmeter lead from the distributor connector and ground it. Again open the vacuum source to the distributor while observing the ohmmeter. A reading less than infinite indicates a defective pickup coil.

IGNITION SCOPE TESTER

In troubleshooting an ignition system, it takes time to remove certain components, such as spark plugs, for the purpose of testing them. A better way is testing the components as they function while the engine is running. The ignition scope tester (oscilloscope) of figure 6-25 is designed to test in this way. It displays on its screen a pattern or waveform that can then be translated into a diagnosis of ignition system problems. The manufacturer of the oscilloscope provides instructions for hooking it up and interpreting the patterns or waveforms shown on the screen. The scope tester is capable of providing vital information about the operating condition of an ignition system. Among the many problems that can be diagnosed with it are: shorted or open ignition coil or condenser, incorrect breaker point gap or dwell, cracked distributor cap, worn or broken rotor, burned breaker points, poorly grounded distributor, damaged spark plug cables, faulty ballast resistor, and spark plug failure.

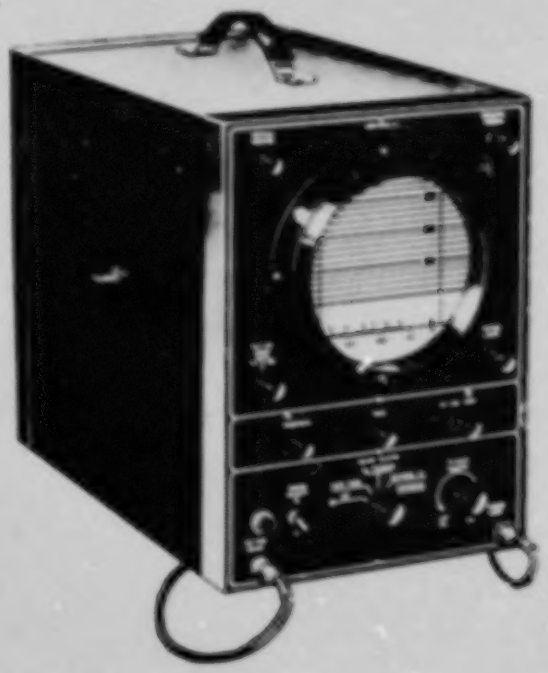

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Figure 6-25.—Ignition scope tester.

CHAPTER 7

DIESEL FUEL SYSTEMS

The fuel and air induction systems are the most crucial of all of the diesel engine systems. Therefore, special care must be exercised when making adjustments and repairs to these systems. The Construction Mechanic 3 & 2, Rate Training Manual, NAVPERS 10644-F edition, covered the general maintenance, removal and replacement of pumps, injectors, blowers, and turbochargers; and, as well, timing, minor adjustments, and repairs to the Caterpillar, International Harvester, General Motors and Cummins diesel fuel systems. This chapter provides information that will aid you in the disassembly, reassembly, testing, overhaul, and troubleshooting of diesel fuel and air induction systems.

CATERPILLAR FUEL INJECTION SYSTEM

The main parts of the Caterpillar fuel injection system are (1) the fuel injection pump (see fig. 7-1) which times, meters, and creates the pressure needed for fuel delivery and (2) the capsule-type injector valve (see fig. 7-2) which injects and atomizes the fuel.

The most likely causes of faulty fuel injection performance are (1) air in the fuel, (2) low fuel supply, (3) water in the fuel, (4) dirty fuel filters, and (5) low transfer pump pressure. If, after you have checked and corrected these conditions, the engine still does not perform properly, the fuel injection components must be checked. The following guidelines for troubleshooting and general test procedures used when testing the injector pumps and valves are given below.

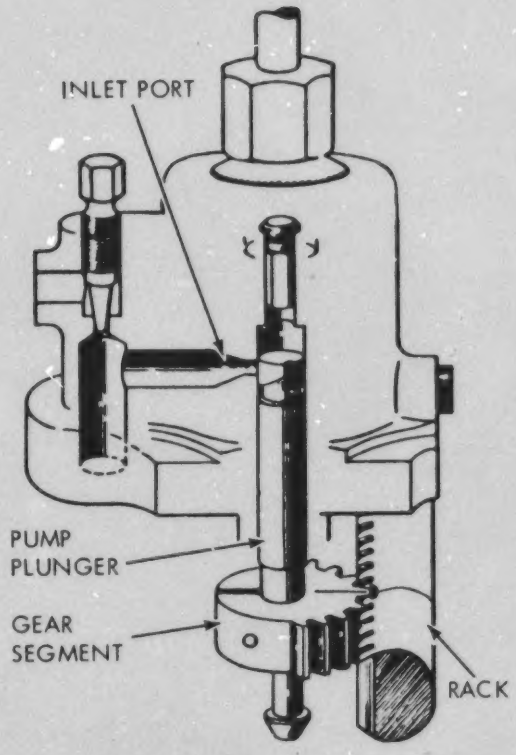

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Figure 7-1. — Fuel injection pump.

TROUBLESHOOTING

Prior to removing either the injector pump or injector valve for testing from an engine that is running erratically, make a simple test by running the engine at a speed which makes the defect most pronounced. Momentarily loosen the fuel nut line on the injector pump far enough so that the cylinder misfires or "cuts out;" check each cylinder in the same manner. If any is found where loosening the nut has no effect on the irregular operation of the engine or black smoke stops puffing from the exhaust, you have located the misfiring cylinder and probably only the pump and valve for that cylinder need be removed for additional testing.

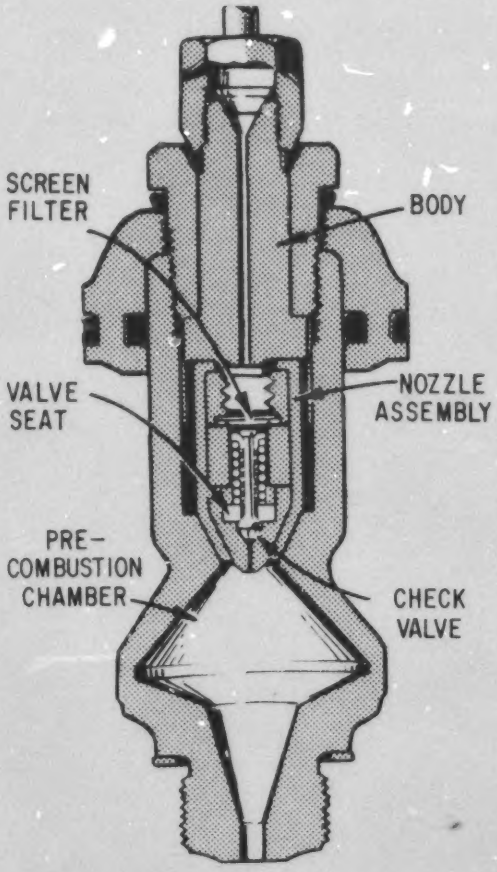

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Figure 7-2.—Capsule type fuel injection valve assembly.

TESTING

The Caterpillar fuel injection test apparatus provides a means for determining the condition of the fuel injection pumps and valves. Prior to performing any test, be sure to study and follow the instructions contained in the manual for the type of testing equipment you are using.

Injector Pumps

Clean the fuel pump thoroughly before installing it on the test apparatus. Any abrasive material allowed to enter the pump may be carried into the testers discharge collector, resulting in impairment of discharge measurement accuracy. Close the fuel pump openings with the covers provided, holding the plunger in place. Clean thoroughly with clean solvent or fuel oil.

Pumps are tested at or near (within .025") the full load setting of the engine. If the fuel delivery from the pump is within limits of the full load setting, the pump will perform properly throughout the full range of rack travel. The governor will compensate for pump wear at any rack setting less than the full load setting.

Caterpillar fuel injection pumps have no adjustments or replacement parts for rebuilding. If the test apparatus reveals that the pump is no longer serviceable, discard the pump.

To test the injector pump, determine the plunger diameter by inserting the portion of the plunger under the gear into the gage supplied with the test apparatus. Insert the portion of the pump plunger and gear segment into the gage setting of the test housing as shown in figure 7-3. Determine the proper full load rack setting by referring to the rack setting charts for the engine from which the pump was removed. After you have made the full rack setting (usually to the

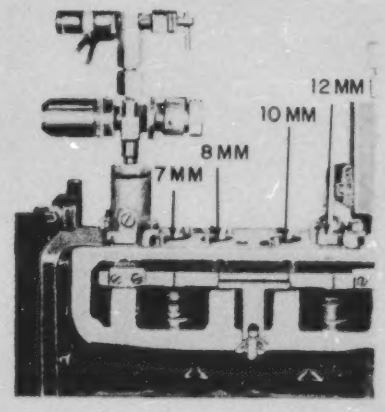

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Figure 7-3.—Test location for various size pumps.

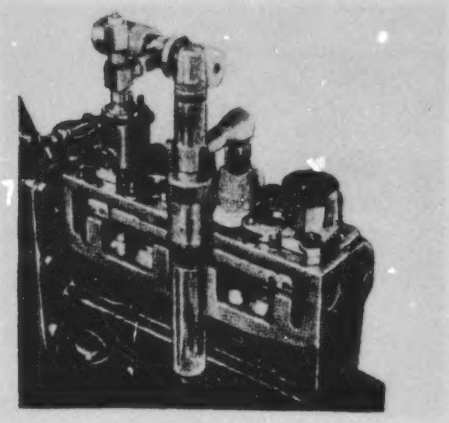

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Figure 7-4.—Collector assembly and jar.

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Figure 7-5.—Correct level in collector jar.

nearest .025"), you also will be able to determine the number of discharge strokes required from the pump test chart. Now you are ready to attach the collector assembly and jar, as shown in figure 7-4, to the fuel pump. It is very important for you to remember to bleed the air from the pump and the collector assembly before proceeding with the test. Operate the pump at least 50 strokes to do this. Remember the collector jar is loosely placed on the collector assembly during the priming. After the priming, remove the collector jar and drain. Re-set the counter to zero and attach the collector jar to the collector assembly. Operate the pump the prescribed number of discharge strokes. Remove the collector jar and place it on a level surface. The fuel level in the jar is to be read from the bottom of the meniscus (curve) as shown in figure 7-5.

The condition of the pump is indicated directly by the calibrations on the collector jar.

1. If the fuel level is within or above the GOOD range, the pump is equivalent to a new one.

2. If the fuel level is in or below the POOR range, it indicates that wear to the pump plunger and barrel has progressed to the point where difficult starting as well as reduced power output of the engine may be encountered. Such pumps should be replaced.

Capsule-Type Injector Valve

The capsule-type fuel injection valves can be tested on the fuel injection test apparatus for spray characteristics, valve opening pressure, and leakage rate. Before testing the valve, inspect the screen filter. (See fig. 7-2.) If the screen is broken or clogged with dirt particles, discard the valve.

When cleaning the deposited carbon from the injection valve nozzle (see fig. 7-6), use a drill from the cleaning tool group kit, furnished by Caterpillar, corresponding to the orifice size of

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Figure 7-6.—Cleaning capsule-type nozzle.

the nozzle. The orifice size is usually stamped on the side of the valve. As a word of caution, injection valves should NEVER be cleaned with a wire brush. Use of a wire brush to remove carbon from the injection valves can result in damage to the orifice and result in greatly reduced power output.

After inspecting the valve screen filter and cleaning the injector valve nozzle, test the valve for spray characteristics. A solid stream of fuel with little or no atomization may be caused either by a gummy carbon accumulation, or the presence of a particle of foreign material.

If the fuel emitted is properly atomized and the cut-off is sharp with no dribble, the spray characteristics of the valve may be considered to be satisfactory.

Next, test the valve for opening pressure and leakage. Valve opening pressure may range from 400 to 800 psi, as registered on the test gage. If the injection valve fails to reach a minimum of 400 psi, discard the valve. If the valve opening pressure is satisfactory, reduce the pressure to 300 psi and observe the gage to note any drop in pressure. If the pressure falls more than 100 psi in 30 seconds, discard the injection valve nozzle.

ROOSA MASTER FUEL INJECTION PUMP AND INTERNATIONAL HARVESTER FUEL INJECTOR

The Construction Mechanic 3 & 2, NAVPERS 10644-F, chapter 9, covers the general construction and operation of the Roosa Master DB and DC fuel injection pumps as well as the International Harvester engine series 817 fuel injector. Here we will cover troubleshooting, disassembly, inspection, reassembly, and testing of the basic DC fuel pump of the Roosa Master system and the International Harvester engine series 817 fuel injector. Prior to performing any work on an injection pump or fuel injector, refer to the manufacturers' maintenance and service manuals.

The troubleshooting chart shown in table 7-1, lists some of the various problems and their possible causes that you may encounter in the Roosa Master fuel system.

PUMP TROUBLESHOOTING

Let's observe how a field test (Kiene) on an engine is put to work as an efficient means in pinpointing the cause of poor engine performance and eliminating unnecessary fuel injection pump removal. Since this field test permits some analysis of engine condition, as well as the fuel system, it is possible for you to be quickly advised as to the extent of the difficulty and the remedies required.

Since most tests are more conveniently made under no load conditions, all readings possible are determined at high idle. If the supply pressure is lower than normal, an engine can still operate smoothly at approximately the correct high idle speed. This will be achieved by the governor opening the metering valve further to compensate for the lower pressure. For this reason, successful readings can be taken at high idle.

First disconnect the throttle linkage, then with the engine running, hold the throttle lever all the way to the rear. Adjust the high idle stop screw until the specified high idle speed is obtained to test the fuel pressure at high idle. Install the gage assembly in the pressure trap of the transfer pump as shown in figure 7-7. If the reading obtained does not fall within the prescribed range, the pump will not deliver sufficient fuel to obtain full power under load. The most common causes of low pressure are restricted fuel supply, air leaks on the suction side of the pump, worn transfer pump blades, or a malfunctioning regulator valve.

To test for excess pressure, remove the injection fuel pump timing plate. Be sure you make a small hole in the timing plate gasket

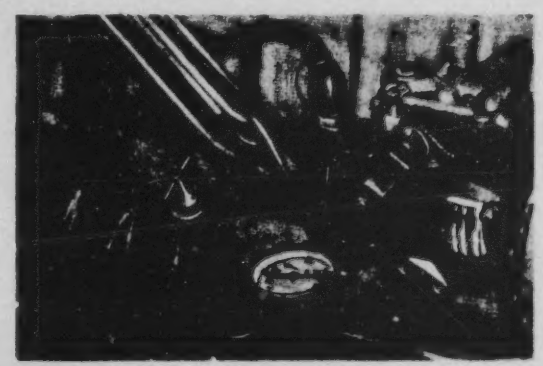

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Figure 7-7. — Gage installed for checking transfer pump pressure.

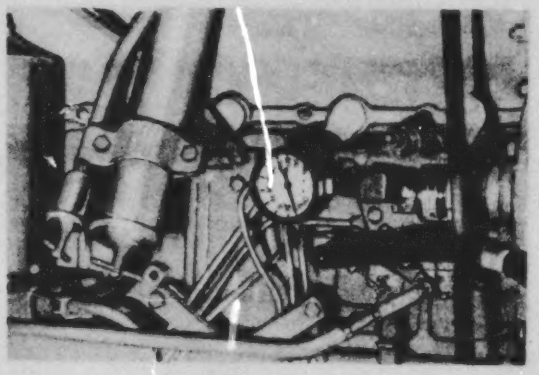

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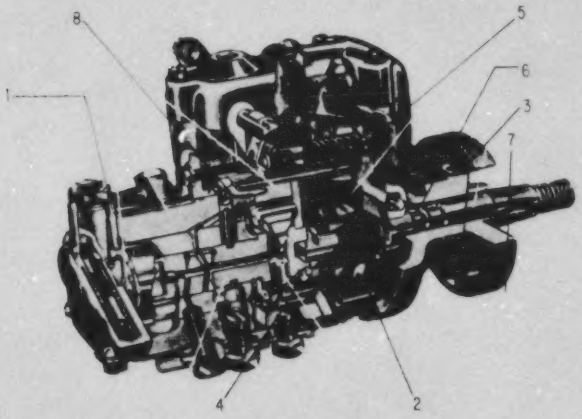
Figure 7-8.—Testing pump housing pressure.



1. Drive Shaft
2. Distributor Rotor
3. Transfer Pump
4. Pumping Plungers
5. Internal Cam Ring
6. Hydraulic Head
7. End Plate
8. Governor

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Figure 7-9.—Roosa Master fuel injection pump.

as you install the gage on the pump. (See fig. 7-8.) This hole allows pump pressure to reach the gage as you operate the engine at both low and high idle. If excessive pressure is encountered, a restricted fuel return line is the probable cause.

To test for restricted fuel supply on the suction side of the pump, operate the engine at high idle and read the vacuum developed. If the vacuum reading exceeds 10 inches Mercury (Hg), check the fuel supply system for dirty filters, pinched or collapsed hoses, or a plugged vent.

PUMP REMOVAL

After field testing, if it is determined that the injection fuel pump must be removed from the engine, be sure to remove all external grease and dirt. Keep in mind that dirt, dust, and other foreign matter are the greatest enemies of the injection fuel pump. As a precaution, keep all openings plugged during removal and disassembly.

PUMP DISASSEMBLY

The workbench and surrounding area must be clean, as well as the tools to be used in disassembly. Have available a clean pan in which parts may be placed as you disassemble and a pan of clean diesel fuel oil in which the parts can be washed and cleaned.

After mounting the pump in a holding fixture, clamp the fixture in a vise. You are now ready for disassembly. For pump disassembly, follow the step-by-step procedure in the manual for the model pump on which you are working. Figure 7-9 illustrates the main internal working parts of the Roosa Master fuel injection pump.

PUMP CLEANING AND INSPECTION

Now that you have disassembled the pump, all parts must be cleaned and inspected carefully.

Check all O-rings, seals, and gaskets for distortion, or damage, and all springs for wear, distortion, or breakage. Clean and carefully check all bores, grooves, and seal seats for damage of any kind. Replace damaged parts as necessary.

Inspect with care each part of the injection pump for excessive wear, rust, nicks, chipping, scratches, cracks, distortion, or binding. Replace any defective parts.

PUMP REASSEMBLY

Reassemble in the manner specified by the manufacturer's maintenance and repair manual.

Table 7-1.–Troubleshooting Chart for Roosa Master Fuel System

CAUSE OF PROBLEM	PROBLEM										CORRECTIVE MEASURES
(Numbers in "Problem" Check Chart indicate order in which to check possible "Causes" of Problem.)	A. Fuel not reaching pump.	B. Fuel delivered from transfer pump but not to nozzles.	C. Fuel reaching nozzles but engine won't start.	D. Engine starts hard.	E. Engine starts and stops.	F. Erratic engine operation--surge, misfiring, poor governor regulation.	G. Engine idles imperfectly.	H. Engine does not develop full power or speed.	I. Engine smokes black.	J. Engine smokes blue or white.	
Hand primer installed backwards.	3										Re-install properly.
One or more Connector Screws obstructed.		3		2					9		Replace.
Seizure of Distributor Rotor.	2										Check for cause of seizure. Replace hydraulic head and distributor rotor assembly.
Failure of electrical shut-off.		2			7						Remove, inspect and adjust parts. Replace parts as necessary.
Fuel supply lines clogged, restricted, wrong size or poorly located.	6	7	5	3	1	2	8	4			Blow out all fuel lines with filtered air. Replace if damaged. Remove and inspect all flexible lines.
Air leaks on suction side of system.	7			4	6	7	3	5			Trouble-shooting the system for air leaks.
Automatic advance faulty or not operating.			8	9		9	8	11	4	2	Remove, inspect, correct and reassemble.
Water in fuel.			3	6	2	5	1	13			Drain fuel system and pump housing, provide new fuel, prime system.
Return oil line or fittings restricted.				11	4	13	11	8			Remove line, blow clean with filtered air and reassemble. Replace if damaged.
Air intake restricted.					3			14	1		Check manual.

Pump housing not full of fuel.						6	2				Operate engine for approximately 5 minutes until pump fills with fuel.
Fuel lines incorrect, leaking or connected to wrong cylinders.			4			1		15			Relocate pipes for correct engine firing sequence.
Shut-off device interfering with Governor linkage.			6	8				2			Check and adjust governor linkage dimension.
Governor high-idle adjustment incorrect.								3			Adjust to pump specifications.
Throttle Arm travel not sufficient.			2					1			Check installation and adjust throttle linkage.
Transfer Pump Blades worn or broken.	5			7	9	12	5	12			Replace.
Shut-off device at "stop" position.		1									Move to "run" position.
Metering Valve sticking or closed.		4		8	8	10	6	10			Check for governor linkage binding, foreign matter, burrs, etc.
Governor Spring worn or broken.		5				11	9				Remove and replace.
Governor linkage broken.		6					10				Remove, replace and readjust per specifications.
Tank valve closed.	1										Open valve.
Nozzles faulty or sticking.			7	10		8	7		3		Replace or correct nozzles.
Pump timed incorrectly to engine.			1	1		4	4	7	2	1	Correct timing.
Filters or Inlet Strainer clogged.	4			5	5	3		6			Remove and replace clogged elements. Clean strainer.

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Figure 7-10.—Injector Test Pump.

INJECTOR (817 SERIES)
TROUBLESHOOTING

By using the field test (Kiene) you can check the condition of an injector prior to disassembly. Remove the injector from the engine and, using the test pump (fig. 7-10), check for injector spray angle and pattern. There are seven orifices in the injector tip and the spray angle should be uniform for all seven. Also check the spray valve opening pressure. A pressure reading that is more than 50 psi below the check valve specified opening pressure indicates a bad check valve or seat. Next test the leakage past the plunger and bushing. If this leakage is excessive install a new plunger and bushing assembly.

Proceed with injector disassembly only after you have performed these and other tests prescribed in the test manual. While testing, record the results of the tests for each individual injector. They can help you determine the nature and extent of repairs necessary.

INJECTOR DISASSEMBLY

Before disassembly of the injector, clean the external area with cleaning fluid or clean diesel fuel oil, using a brush with long bristles.

Keep the disassembled injectors separated to prevent mixing the various injector components. During inspection, reference should be made to the test results and used as a guide in determining the extent of reconditioning necessary.

Figure 7-11 shows an exploded view of an injector, which will enable you to identify the various component parts.

INJECTOR CLEANING
AND INSPECTION

After you have disassembled the injector, make sure each disassembled injector has been placed in a separate pan containing a cleaning solvent or clean diesel fuel oil. Soak the injector tips in a good carbon solvent for the length of time prescribed by the manufacturer. As a word of caution, remember not to mix the injector tips together. Each tip must be reassembled with its own group of injector parts.

Be careful when cleaning the spray holes of the injector tip so as not to enlarge or damage them. Use a magnifying glass as you inspect the tip for signs of scratches in the plunger tip seat, or flat lapped surface. Inspect for a cracked tip if there was leakage at the tip. Also check the plunger and bushing, making sure they do not bind.

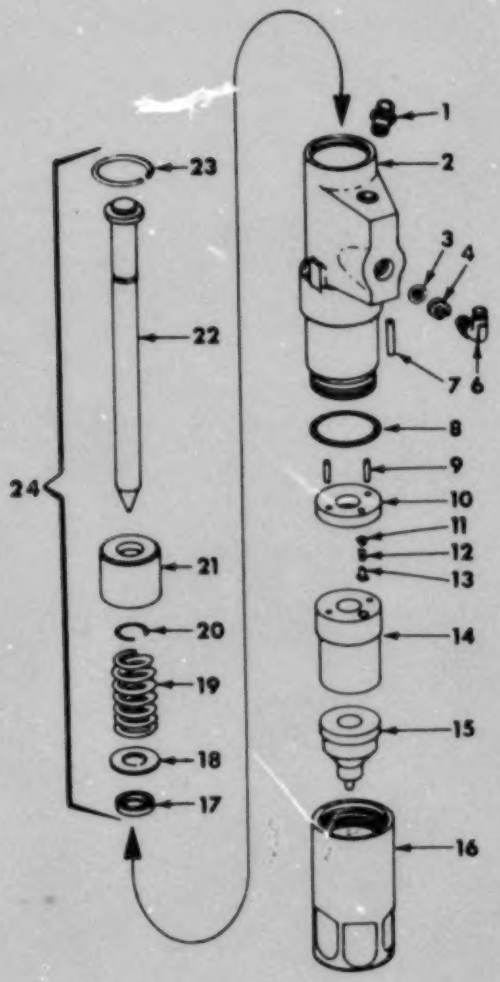
After cleaning and inspection, the injector components that must be reconditioned by lapping (see fig. 7-11) are the injector tip (15), the injector bushing (14), the check valve (11), the check valve plate (10), and the bottom of the injector body (2).

INJECTOR REASSEMBLY

Reassemble the injector in the manner prescribed and specified by the manufacturer's maintenance and repair manual.

CHECKING THE
INJECTOR AFTER REASSEMBLY

Before you install the injector in the engine, retest it for (1) spray angle and pattern, (2) valve opening pressure, (3) leakage through



1. Return line connector.
2. Injector body.
3. Screen.
4. Retaining spring.
6. Inlet pipe elbow.
7. Dowel pin.
8. Body "O" ring.
9. Valve plate dowel.
10. Check valve plate.
11. Check valve.
12. Check valve spring.
13. Check valve stop.
14. Injector bushing.
15. Injector tip.
16. Tip holding nut.
17. Plunger oil seal.
18. Spring seat washer.
19. Plunger spring.
20. Snap ring.
21. Spring cup.
22. Plunger.
23. Snap ring.
24. Plunger assembly.

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Figure 7-11.—Exploded view of an injector (817 series engine).

the orifice tip, (4) leakage past the plunger and bushing, and (5) leakage between the injector tip and body. If the test results are good, then install injector in engine.

GENERAL MOTORS FUEL SYSTEM

The General Motors fuel system includes fuel injectors, fuel pipes, fuel manifolds, fuel pump, fuel strainer, fuel filter, and fuel lines connecting the fuel tank. On this system depends the injection of the correct amount of fuel at exactly the right time into the combustion chamber. Efficient engine operation demands that the fuel system be maintained in first-class condition at all times. This will necessitate the use of only clean, waterfree fuel. Good maintenance of the fuel filtering system and reasonable care in handling fuel is the key to a trouble free fuel system.

Servicing the fuel system is not a difficult task and may be performed by most of your mechanics. However, due to the close tolerances of the various fuel system components, extreme cleanliness and strict adherence to service instructions is required.

Here we will cover troubleshooting, disassembly, inspection, reassembly, and testing of the fuel pump and fuel injector. Prior to performing any work on these components, refer to the manufacturer's maintenance and service manuals.

TROUBLESHOOTING

When a piece of equipment is brought into the shop for maintenance and servicing, the hard card or EWO may show a fuel system problem. As you know, a means of pinpointing the problem is by troubleshooting the fuel system until the trouble is located.

Check the fuel lines for improper or faulty connections. If any leaks occur, tighten the connection only enough to stop the leak. Also, check the filter cover bolt for tightness. If the fuel pump fails to function satisfactorily, first check the level of the fuel tank, then make sure the fuel supply valve is open. Check for a broken pump driveshaft or drive coupling by inserting the end of a wire through one of the pump flange drain holes, then crank the engine and note if the wire vibrates. Vibration will be felt if the pump shaft is turning.

Most fuel pump failures result in no fuel or insufficient fuel being delivered to the fuel injectors, and may be indicated by uneven running of the engine, excessive vibration, stalling at idling speeds, or a loss of power.

The most common failure of a fuel pump is a sticking relief valve. The relief valve, due to its close fit in the valve bore, may stick in a fully open position due to a small amount of grit or foreign material lodged between the relief valve and its bore or seat. This permits the fuel oil to circulate within the pump rather than being forced through the fuel system. Therefore, if the fuel pump is not functioning properly, remove the fuel pump from the engine. Then, remove the relief valve plug, spring, and pin, and check the movement of the valve within the valve bore. If the valve sticks, recondition it by using fine emery cloth to remove any scuff marks. Clean the valve bore and the valve components. Then, lubricate the valve and check it for free movement throughout the entire length of its travel. If its operation is satisfactory, reassemble the valve in the pump. If not, replace it.

After the relief valve has been checked, and the fuel pump reinstalled on the engine, start the engine and check the fuel flow at some point between the restricted fitting in the fuel return manifold and the fuel tank.

If, after making the above checks, there is still a lack of power, uneven running, excessive vibration, or stalling at idle, suspect a faulty injector in one or more cylinders. Start the engine and run it at part load until it reaches normal operating temperature. Remove the valve rocker cover(s) and then let the engine run at idle speed. Hold the injector follower down with a screwdriver, thus preventing operation of the injector. If the cylinder has been misfiring, there will be no noticeable difference in the sound or operation of the engine. If the cylinder has been firing properly, there will be a noticeable difference in the sound and operation when the follower is held down. If that cylinder is firing properly, repeat the procedure on the other cylinders until the faulty one has been located.

Provided that the injector operating mechanism of the faulty cylinder is functioning satisfactorily, remove the fuel injector for additional testing.

TESTING

The General Motors injector tester provides a means for determining the condition of the injector to avoid unnecessary overhauling. An injector that passes all of the tests outlined below may be considered to be satisfactory for service without disassembly, except for the visual check of the plunger. However, an injector that fails to pass one or more of the tests is unsatisfactory. Be sure to identify each injector and record the pressure drops and fuel output during the tests. Also remember, all tests must be performed BEFORE the injector is disassembled.

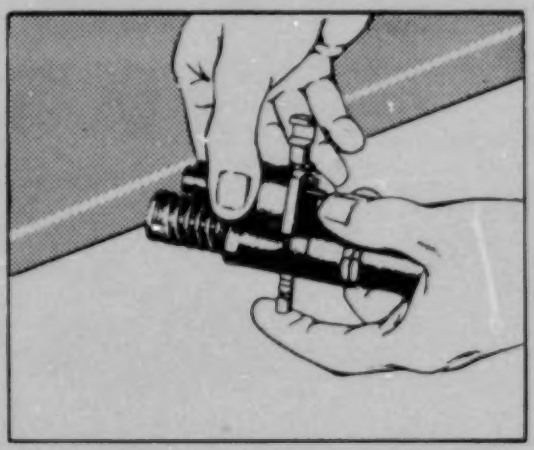

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Figure 7-12. — Checking rack and plunger freeness.

To perform the INJECTOR CONTROL RACK AND PLUNGER MOVEMENT TEST, place the injector against a bench, as shown in figure 7-12, and depress the follower to the bottom of its stroke while moving the rack back and forth. Failure of the rack to move freely indicates that the internal parts of the injector are damaged or dirty.

CAUTION: The injector must always be held in such a way as to prevent any fuel spray from penetrating the skin. Fuel oil which enters the bloodstream might well cause blood poisoning.

The purpose of the VALVE OPENING PRESSURE TEST is to determine the pressure at which the valve opens and injection begins. Place the injector in the tester (see fig. 7-13). Operate

the pump handle until all of the air is purged from the injector tester and the injector. Then close the outlet clamp. As a word of caution, when testing an injector just removed from the engine, the flow of fuel through the injector on the tester should be the same as it was on the engine. If required, fuel connections on the tester may be reversed to obtain the proper fuel flow.

With the injector rack in the full-fuel position, pump the handle of the injector tester with smooth even strokes (see fig. 7-14) and record the injector valve opening pressure. The specified valve opening pressure for the Crown Valve injector is 450 to 850 psi. For the Needle Valve injector the specified opening pressure is 2300 to 3300 psi. If the pressure is not within limits, check the manufacturers' maintenance manuals for probable causes and corrections.

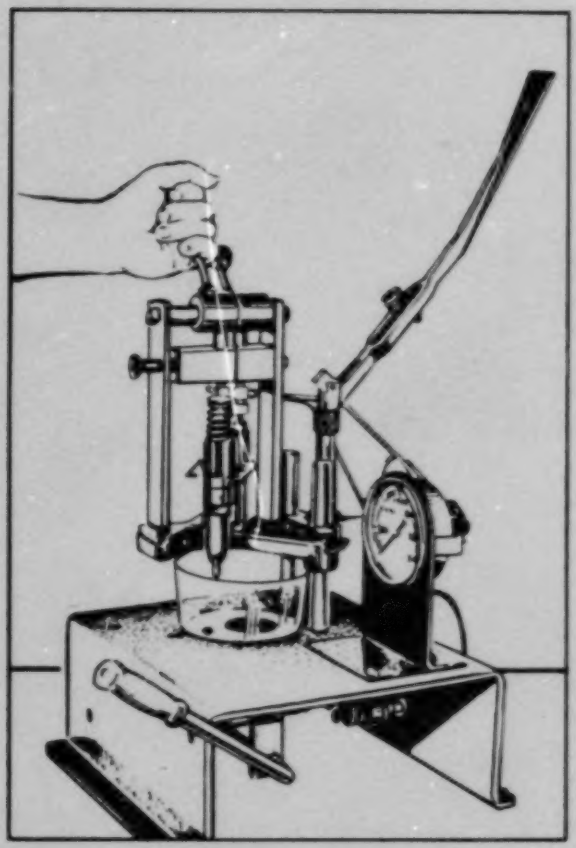

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Figure 7-13.—Injector installed in tester.

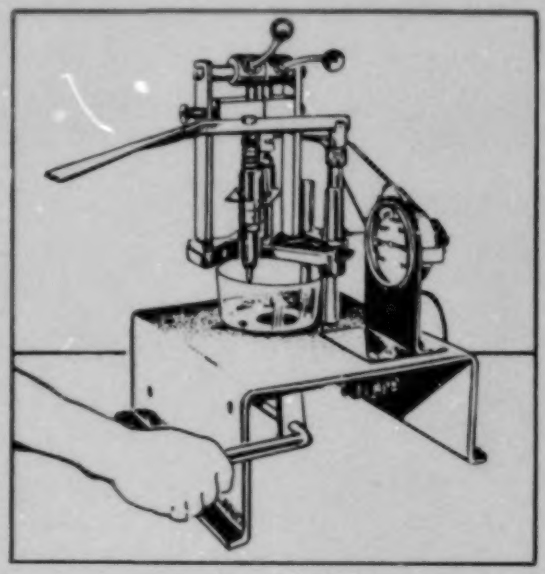

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Figure 7-14.—Checking injector valve opening pressure.

The VALVE HOLDING PRESSURE TEST will determine whether the various lapped surfaces in the injector are sealing properly.

By bringing the pressure up to a point just below the valve opening pressure (450 psi for both Crown and Needle Valve injectors), and then closing off the fuel shut-off valve, the pressure will drop. The time for the pressure to drop from 450 psi to 250 psi must not be less than 40 seconds. If the injector pressure drops from 450 psi to 250 psi in less than 40 seconds, check the injector as follows:

1. Thoroughly dry the injector with compressed air.
2. Open the injector tester fuel valve and operate the pump to maintain the test pressure.
3. Check for a leak at the injector rack opening. A leak indicates a poor bushing-to-body fit.
4. A leak around the spray tip or seal ring usually is caused by a loose injector nut, a damaged seal ring, or a burned surface on the injector nut or spray tip.

5. A leak at the filter cap indicates a loose filter cap gasket.

6. A "dribble" at the spray tip orifices indicates a leaking valve assembly due to a damaged surface or dirt. Leakage at the tip will cause pre-ignition in the engine.

NOTE: A drop or two of fuel at the spray tip is only an indication of the fuel trapped in the spray tip at the beginning of the test and is not detrimental as long as the pressure drop specified is not less than 40 seconds.

The HIGH PRESSURE TEST is performed to discover any fuel leaks at the injector filter cap gaskets, body plugs, and nut seal ring, which did not appear during the valve holding pressure test. The HIGH PRESSURE TEST also indicates whether or not the injector plunger and bushing clearance is satisfactory.

Place the injector rack in the FULL-FUEL position, operate the pump handle (see fig. 7-15) to build up and maintain the pressure of 1600 to 2000 psi. Then, inspect for leaks at the injector filter cap gaskets, body plugs, and injector nut seal ring.

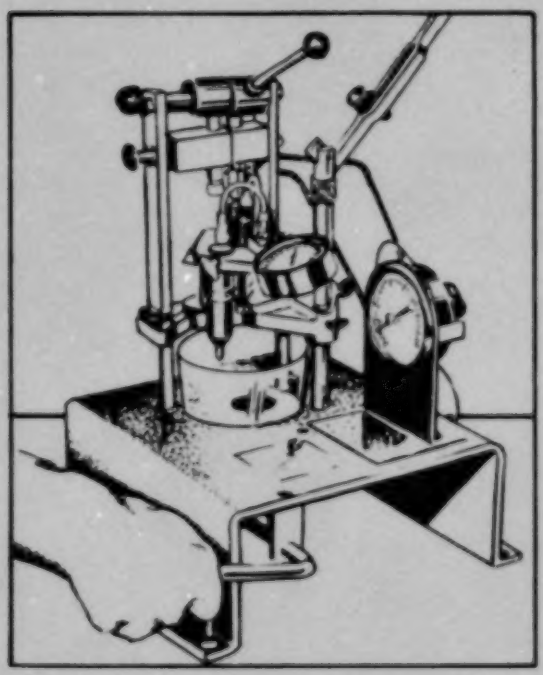

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Figure 7-15. — Injector high pressure test.

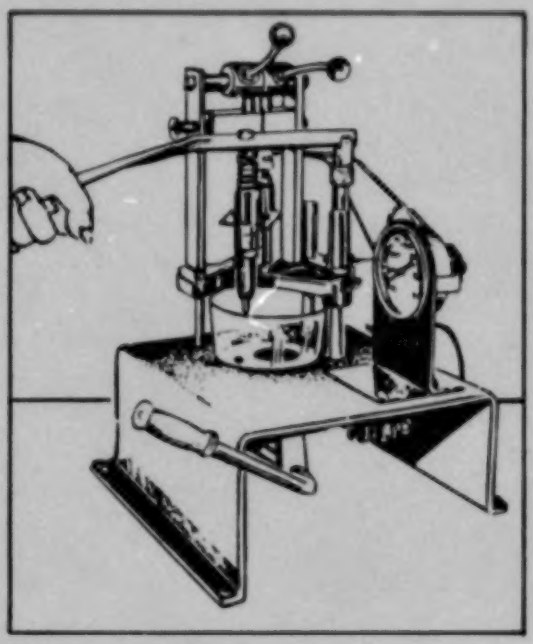

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Figure 7-16. — Spray pattern test.

Use the adjusting screw in the injector tester handle to depress the injector plunger just far enough to close both ports in the injector bushing. The point at which both ports are closed may be ascertained by the fact that the injector spray will decrease and a rise in the pressure will be noted. At this time, the condition of the plunger and bushing may be established. If there is excessive clearance between the plunger and bushing, pressure beyond the normal valve opening pressure will not be obtained. Replacement of the plunger and bushing assembly will be required.

A SPRAY PATTERN TEST is performed after completing the valve holding pressure test. After placing the injector in the tester, open the fuel shut-off valve, then place the injector rack in the FULL-FUEL position and operate the injector several times in succession by operating the tester handle (see fig. 7-16) at approximately 40 strokes per minute. Observe the spray pattern

to see that all of the spray tip orifices are open and injecting evenly. The beginning and ending of injection should be sharp and the fuel injected should be finely atomized.

If all the spray tip orifices are not open and injecting evenly, clean the orifices in the spray tip during injector overhaul.

CAUTION: To prevent damage to the pressure gage, do not exceed 250 psi during this test.

A visual inspection of the injector plunger should be made even if the injector passes all of the previous tests. The plunger is visually checked under a magnifying glass for excessive wear or a possible chip on the bottom helix. There is a small area on the bottom helix and the lower portion of the upper helix, that, if chipped, will not be indicated in any of the tests.

A FUEL OUTPUT TEST is performed to check injector fuel output. To test the injector, place it in the comparator (see fig. 7-17) and seal the injector firmly by tightening the hand wheel. Pull the injector rack out to the NO FUEL position and start the comparator. After the comparator has started, push the injector rack to the FULL FUEL position. Let the injector run for approximately 30 seconds to purge any air that may be in the system. After 30 seconds, press the fuel flow start button. This will start the flow of fuel into the vial. The comparator will automatically stop the flow of fuel after a thousand strokes. After the fuel has stopped flowing into the vial, be sure to pull the injector rack out to the NO FUEL position. Turn the comparator off, reset the counter, and observe the reading on the vial. Refer to the chart on the comparator and check to see if the injector fuel output falls within its specified limits. If the quantity of fuel in the vial does not fall within the specified limits, refer to the manufacturer's manuals for the cause and remedy.

Any injector which has been disassembled and rebuilt must be tested again before being placed in service.

INJECTOR DISASSEMBLY

An injector to be disassembled is placed in the injector assembly fixture to remove filter caps, springs, filter elements, and gaskets. Be sure to discard the filter elements and gaskets, replacing them with new components during reassembly.

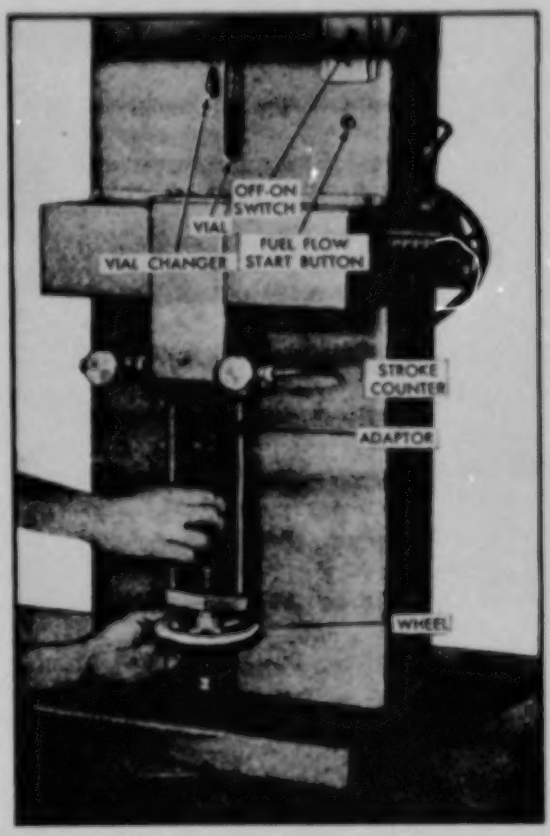

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Figure 7-17.—Comparator used to check injector fuel output.

Disassembly is completed in the manner prescribed by the manufacturer's repair and maintenance manual.

INJECTOR CLEANING AND INSPECTION

After disassembly of the injector, be sure you keep each injector and its component parts together in a separate receptacle containing a cleaning solvent or clean diesel fuel oil.

Wash all the parts and dry them with clean, filtered, compressed air. Do not use waste or rags for cleaning purposes. Clean out all passages, drilled holes, and slots in all of the injector parts.

Injector spray tips should be soaked in a suitable solvent for approximately 15 minutes to loosen the carbon on the inside of the tip. Then they can be reamed out by using the proper size spray tip cleaning wire.

Inspect injector parts for excessive wear, damage, defects, burrs, scratches, scoring, erosion, or chipping. Replace damaged or excessively worn parts.

Before reinstalling used valve parts in an injector, lap all of the sealing surfaces such as the bottom of the injector body, the injector bushing, the valve seat, the valve cage, the check valve, and the spray tip.

INJECTOR REASSEMBLY

As with the other type injectors mentioned in the previous sections of this chapter, reassembly of the injector will be in the manner prescribed by the manufacturer's maintenance and repair manuals.

CHECKING THE INJECTOR AFTER REASSEMBLY

Before placing a reconditioned injector in service, perform all of the tests (except the visual inspection of the plunger) previously outlined under the heading "Testing."

The injector is satisfactory if it passes these tests. Failure to pass any one of these tests indicates that defective or dirty parts have been assembled. In this case, disassemble, clean, inspect, reassemble, and test the injector again.

CUMMINS PRESSURE TIME FUEL SYSTEM

The Cummins Pressure Time (PT) Fuel System consists of the fuel pump (with governor and Aneroid valve), the supply and drain lines, and the injectors.

As in previous sections of the chapter we will cover troubleshooting, disassembly, inspection, reassembly, and testing of components. Remember, before performing any service on the PT injector or pump, refer to the manufacturer's maintenance and repair manuals.

TROUBLESHOOTING

As you know, troubleshooting is nothing more nor less than an organized study of the problem and a planned method of procedure for the investigation and correction of the difficulty.

Most troubles are simple and easily corrected; examples are "excessive fuel oil consumption" caused by leaking gaskets or connections, etc. A complaint of "sticking injector plunger" is usually corrected by repairing or replacing the faulty injector, but something caused the plunger to stick. The cause may be improper injector adjustment, or, more often, water in the fuel.

In general, the complaint of "low-power" will be the most troublesome to correct because of the many variables in operation and installations, as well as the difficulty of correctly measuring power in the field. With the PT fuel system, you can often eliminate the pump as a source of trouble simply by checking to see that the manifold pressure is within specified limits. The fuel rate of the pump must not be increased to compensate for a fault in other parts of the engine; damage to the engine will result.

To check the fuel pump on the engine, remove the pipe plug from the pump shut-off valve and connect the pressure gage line. At governed speed (just before the governor cuts in) maximum manifold pressure should be obtained. If the manifold pressure is not within specified limits, adjust for maximum manifold pressure by adding or removing shims from under the nylon fuel adjusting plunger in the by-pass valve plunger. Take care not to lose the small lockwasher which fits between the fuel adjusting plunger and the plunger cap.

To check the suction side of the pump, connect the suction gage to the inlet side of the gear pump. The valve in the pump, if properly adjusted, should give a reading of 8 inches on the gage. When the inlet restriction reaches 8.5 to 9 inches, a fuel filter element change should be made or any other sources of restriction removed. The engine will lose power when the restriction is greater than 10 to 11 inches.

Always make the above checks on a warm engine and operate the engine for a minimum of 5 minutes between checks to clear the system of air.

When pump manifold and suction pressures are within specified limits and there is still a loss of power, the injectors must be checked.

Carboning of the PT injector metering orifices restricts the fuel flow to the injector cups with a resulting engine power loss. Carbon can be removed from the metering orifices by reverse flushing; it should be performed on a warm engine.

Loosen all injector adjusting screws one turn from the bottom or one and one-eighth turns from the set position. Lock with the jamnut after completing the required turns.

Start the engine and accelerate with maximum throttle from idling to high—10 to 15 times.

Readjust the injectors to their standard setting.

It might well be noted that the engine will be difficult to start with the loose injector setting—it will smoke badly and will be sluggish. By the injector adjusting screws being loosened, the metering orifice will not be closed during injection. Extremely high injection pressure will force some of the fuel to back-flow through the orifice and should remove carbon deposits. If this method is not effective, remove the injectors for cleaning.

You may encounter an Aneroid control device when working on the PT fuel system of a turbocharged Cummins engine. The function of this device is to create a lag in the fuel system so that its response is equivalent to that of the turbocharger, thus controlling the engine smoke level.

It is recommended that the Aneroid not be removed, disconnected, or otherwise rendered ineffective on this engine, nor should the settings be altered. The exception, of course, is during troubleshooting of the fuel system when the Aneroid is checked according to the manufacturer's specifications, as are other components of the fuel system.

PT FUEL PUMP DISASSEMBLY

If it is determined after troubleshooting that the fuel pump (see fig. 7-18) must be removed from the engine, be sure the pump is cleaned of all dirt accumulation. Be sure the shop area is clean, use clean tools, and that good cleaning practices are used, for they are essential to good

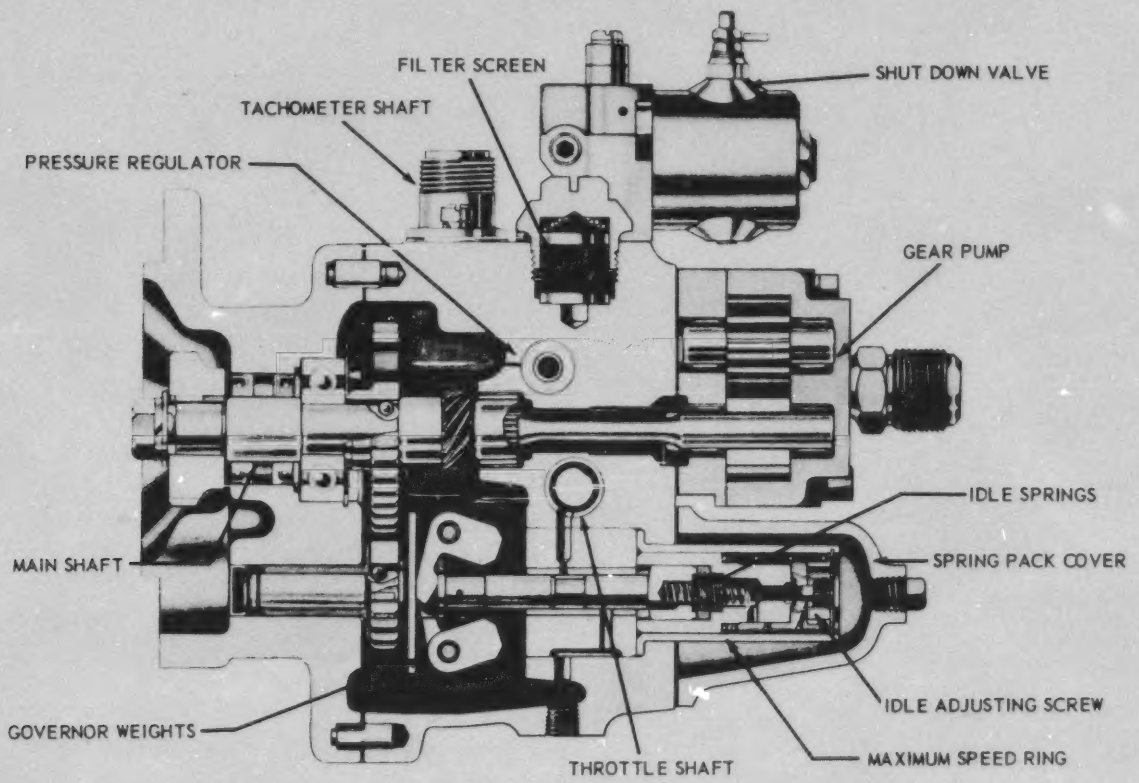

Figure 7-18.—Cummins PT fuel pump. 2.72X

quality fuel pump repair. Special care must be taken when disassembling the PT fuel pump which is made of a lightweight aluminum alloy. Be sure proper tools are used which will prevent damage to its machined surfaces, which are more easily damaged than parts made of cast iron.

Always try to determine the need, if possible, before disassembling the unit as to which parts need replacement.

After placing the fuel pump on the holding device, place the device in a vise and proceed with the disassembly of the pump. Follow the procedures given in the manufacturer's maintenance and repair manual.

PUMP CLEANING AND INSPECTION

Now that the pump has been disassembled, clean and inspect all components parts. Parts must not be discarded until they are worn beyond reasonable replacement limits. The PT fuel pump parts will continue to function long after they show some wear. Parts that are considered to be worn beyond reasonable replacement limits must not be reused. From experience you will quickly learn the "reasonable replacement limits," and reuse all those parts that will give another complete period of service without danger of failure.

NOTE: Special care must be taken when cleaning aluminum alloy parts. Some cleaning solvents will attack and corrode aluminum. Mineral spirits is a good neutralizer after using cleaning solvents.

PUMP REASSEMBLY

After a complete cleaning and inspection of the pump and pump parts, the pump is reassembled in the manner prescribed by manufacturer's manuals. In all assembly operations, be careful to remove burrs and use a good extreme pressure lubricant on the mating surfaces during all pressing operations. An extreme pressure lubricant aids in pressing and prevents scoring and galling.

Flat steel washers are used throughout; they go next to the aluminum to prevent goring by the spring steel lockwashers.

PUMP TESTING

The PT fuel pump is mounted on a test stand as shown in figure 7-19. The test procedure involves the measurement and adjustments of the pressure developed by the PT fuel pump in a simulated operation before it is placed on the engine.

Pressure is developed across special orifices in the orifice block assembly and is measured on the gages provided.

All pump tests should be made with the testing fuel oil temperature between 90 and 100 degrees Fahrenheit.

Open the fuel shut-off valve and manifold orifice valve. Open the stand throttle, start and run the pump at 500 rpm until the manifold pressure gage shows the recommended pressure. If the pump does not pick up the specified pressure — check for closed valves in the suction line or for an air leak.

If the pump is newly rebuilt, run at 1500 rpm for five minutes to flush the pump and allow

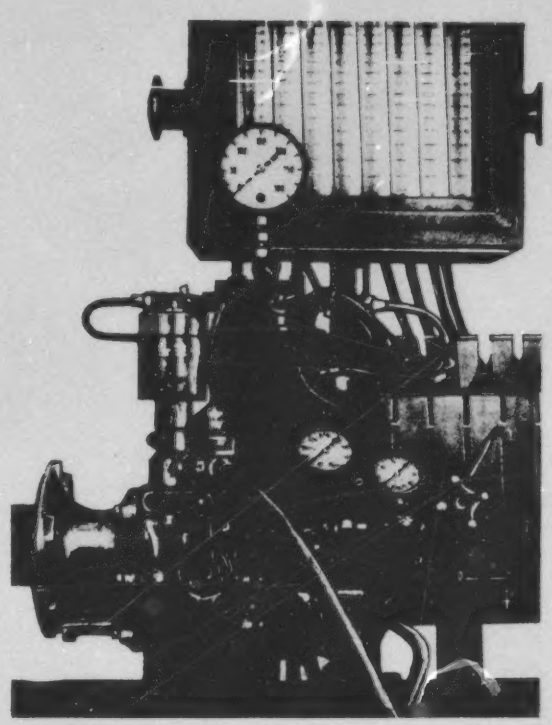

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Figure 7-19. — PT pump mounted on test stand.

the bearings to seat. Continue to run the pump at 1500 rpm and turn the rear throttle stop screw in or out to find the maximum manifold pressure at full throttle.

NOTE: With a standard governed pump the throttle screws will be readjusted later.

If the pump has a variable speed governor, the throttle shaft is locked in full throttle position; do not readjust.

On a dual or torque converter governor pump, the throttle must be locked in shut-off position and the converter driven governor idle adjusting screw turned "in" until the spring is compressed. The converter driven governor must be set on the engine.

The pump idle speed setting is accomplished by closing the by-pass and manifold orifice valves and opening the idle orifice valve. Set the pump throttle to idle and run at 500 rpm. To decrease or raise the idle pressure, add or remove shims from under the idle spring. Remember not to set the idle screw until you have adjusted the throttle screws.

Once the tests and adjustments have been completed in accordance with the specifications recommended by the manufacturer, remove the pump from the test stand, making sure that the suction fitting is not removed or disturbed. Next, loosen the spring pack cover and drain the pump through the pipe plug at the bottom of the pump body. Be sure to cover all openings and bind fittings with tape until you are ready to install the pump.

PT INJECTOR MAINTENANCE AND TESTING

In the PT fuel system, fuel metering is accomplished by fuel pressure against the injector's metering orifice. Any change in fuel pressure, metering orifice, or timing will affect the amount of fuel delivered to the combustion chamber.

There are two things which will interfere with the normal functions of injector orifices:

1. Dirt or a carbon accumulation in the orifices or in the passages to and from the orifices;
2. A change in the size or shape of the orifices, particularly caused by wrong cleaning methods used on the orifices.

After soaking dirty injectors in a cleaning solvent to remove the carbon, be sure to dip the injectors into a neutral rinse, such as mineral spirits, and then blow them clean with filtered compressed air.

NOTE: Never use cleaning wires on PT fuel injector orifices.

Be sure to use a magnifying glass to inspect the injector orifices for damage. When the injector orifices are damaged they cannot be made to function properly and must be replaced.

Check the injector for a worn plunger or injector body. Worn injectors may cause engine oil dilution from excessive plunger to body clearances. Dilution may also occur as a result of a cracked injector body or cup, or a damaged "O" ring. To check the injector for leakage, it must be assembled. Remember to plug off the injector inlet and drain connection holes, then mount it on the injector test stand.

Test the injector at a maximum of 1,000 psi with the fuel flowing upward through the cup spray holes. If the counterbore at the top of the injector body fills with fuel in less than 15 seconds, the plunger clearance is excessive and may cause engine oil dilution. During this check, inspect the injector for leaks around the injector cup, body, and plugs. If the injector does not pass the test and checks, remove the damaged parts and replace with new parts.

Any time you remove an injector plunger, be sure to use the lubricant recommended by the manufacturer upon replacing the plunger in the injector body.

If the injector plunger does not seat in the injector cup, change the cup rather than trying to lap the plunger and cup together. Lapping will change the relationship between the plunger groove and metering orifice, and disturb fuel metering. Always use a new injector cup gasket when you assemble the cup to the injector body to avoid distortion of the cup. When the cup is tightened to the injector body, the gasket compresses everywhere except under the milled slot on the end of the injector body; then, if the gasket is reused, the uncompressed areas may cause the injector cup to cock and prevent the injector plunger from seating properly.

AIR INDUCTION SYSTEM

As you know, the purpose of an air intake system is to supply the air needed for combustion

of the fuel. In addition, the air intake system of a diesel engine will have to clean the intake air, silence the intake noise, furnish air for supercharging, and supply scavange air in two-stroke engines.

The three major components of the air induction system which increase internal combustion engine efficiency are blowers, superchargers, and turbochargers. They may be of the centrifugal or rotary type, or they may be gear driven directly from the engine, belt or chain driven, or driven by the flow of exhaust gases from the engine.

BLOWERS

Scavenging blowers are used to clear the cylinders of exhaust gases to introduce a new charge of fresh air. Superchargers and turbochargers are used to increase the power output of specific engines by forcing air into the combustion chambers so that an engine can burn more fuel and develop more horsepower than if it were naturally induced.

We will cover, in the following sections, certain abnormal conditions of air induction system components which sometimes interfere with satisfactory engine operation. Also, methods of determining causes of such conditions will be covered. Prior to performing any work on these components, make sure you follow the recommendations given in the manufacturer's service manual.

Blower Inspection

The blower, as shown in figure 7-20, may be inspected for any of the following conditions without being removed from the engine. However, the air silencer or air inlet housing must be removed. A word of caution; when inspecting a blower on an engine with the engine running, keep fingers and clothing away from moving parts of the blower and be sure to run the engine at low speeds only.

Dirt or chips, drawn through the blower, will make deep scratches in the rotors and housing and throw up burrs around these abrasions. If the burrs cause interference between rotors or between rotors and blower housing, the blower should be removed from the engine and the parts dressed down to eliminate this interference or the rotors should be replaced if they are too badly scored.

Leaking oil seals are determined by the presence of oil on the blower rotors or inside surfaces of the housing. This condition may be checked by running the engine at low speed and directing a light into the rotor compartment at the end plates and oil seals. A thin film of oil radiating away from the seal is indicative of an oil leak.

A worn blower drive, resulting in a rattling noise inside the blower, may be detected by grasping the top rotor firmly and attempting to rotate it. The rotor may move from 3/8" to 5/8", measured at the lobe crown. When released, the rotor should move back at least one quarter inch. If the rotor cannot be moved this distance, or if the rotor moves too freely, the flexible blower drive coupling should be inspected and replaced, if necessary.

If a check shows the drive coupling to be worn, the blower drive assembly may be removed from the cylinder block end plate. After the blower has been removed from the engine, the drive gear hub bearing support-to-cylinder block end plate bolts are removed.

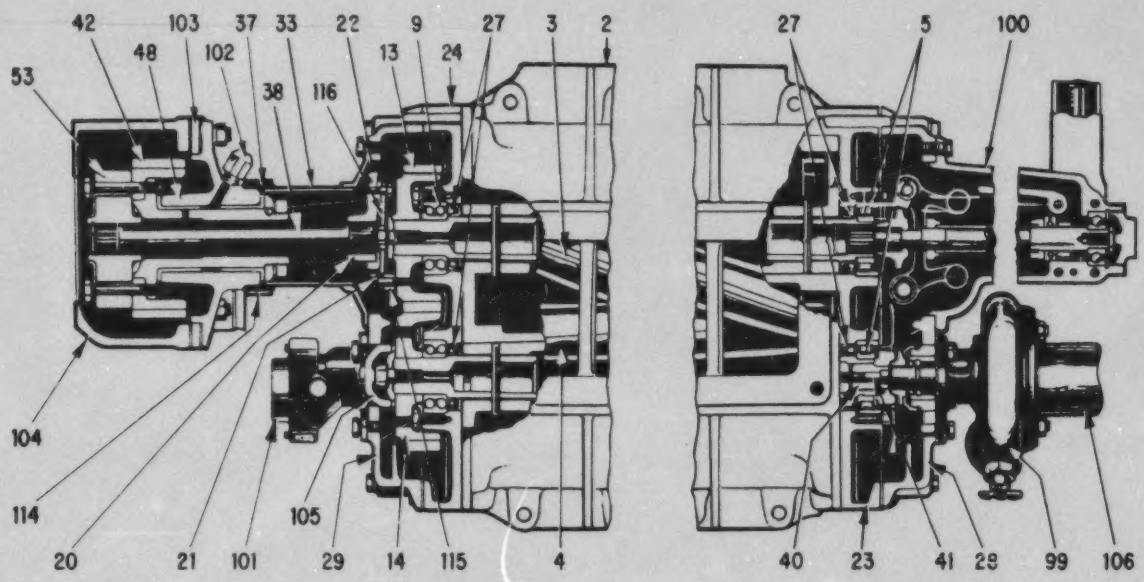
Loose rotor shafts or damaged bearings will cause rubbing and scoring between the crowns of the rotor lobes and the mating rotor roots, between rotors and end plates, or between rotors and the blower housing. Generally a combination of these conditions exists.

Excessive back-lash in blower timing gears usually results in rotor lobes rubbing throughout their entire length.

To correct any of the above conditions, the blower must be removed from the engine and either repaired or replaced.

The blower inlet screen should be inspected periodically for accumulation of dirt which, after prolonged operation, may affect the air flow. Servicing of the screen consists of thoroughly washing it in clean fuel oil and cleaning with a stiff brush until the screen is free of all the dirt deposits.

The air box drains should be open at all times. A periodic check is recommended and, if necessary, the passages should be cleaned. Liquid accumulation on the air box floor indicates a drain tube may be plugged. Such accumulation can be seen after the cylinder



2. Housing
3. Rotor, Blower, Upper
4. Rotor, Blower, Lower
5. Bearing, Front
9. Bearing, Rear
13. Gear, Rotor, Upper
14. Gear, Lower, Rotor
20. Hub, Rotor Drive
21. Bolt
22. Bolt
23. End Plate, Front
24. End Plate, Rear
27. Seal, Oil, Rear
28. Cover, End Plate, Front
104. Housing, Flywheel
106. Cover, Water Pump Inlet
115. Plate, Blower Rotor Drive Hub
29. Cover End Plate Rear
33. Cover, Blower Drive Shaft
37. Seal, Drive Shaft Cover
38. Shaft, Blower Drive
40. Shaft Coupling
41. Bolt
42. Gear Blower Drive
48. Support
53. Coupling Assembly
99. Pump Fresh Water
100. Housing, Governor Weight
101. Pump, Fuel
102. Elbow
103. End Plate
105. Fork
114. Clamp, Drive Cover Seal
116. Spacer, Plate to Gear

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Figure 7-20. — Blower and drive assembly and accessories.

block handhole covers are removed. The accumulation should be wiped out with rags or blown out with filtered compressed air. Then remove the drain tubes and connectors from the cylinder block and clean them thoroughly.

Blower Removal and Disassembly

Having inspected the blower and determined the extent of reconditioning necessary, remove and disassemble the blower. Proceed in accordance with the instructions contained in the manufacturer's maintenance and service manual.

After the assembly has been removed, be careful when disassembling not to damage any parts. Be sure you use the proper tools and follow recommended disassembly procedures, particularly when removing the blower drive, driven gears, and timing gears from the rotor shafts.

They must be pulled from the rotor shafts at the same time or damage to the rotors will occur.

Cleaning and Inspecting

After the blower has been disassembled, all parts should be washed in cleaning solvent or clean fuel oil, blown dry with filtered compressed air, and inspected before reassembly.

Wash the bearings by rotating them by hand in either the cleaning solvent or fuel oil until they are free from grease and foreign matter. Clean the balls (or rollers) and races by directing air through the bearing, at the same time, rotating by hand. Do not spin the bearing with air pressure.

After cleaning thoroughly, again rotate the bearing by hand and inspect it for rough spots. The bearings should run free and show no indications of roughness. The double-row bearings are preloaded and have no end play. A new double-row bearing will seem to have considerable resistance to motion when revolved by hand.

Check oil seals in the end plates and, if necessary, replace. When the blower is being reconditioned, the installation of new seals is recommended.

Inspect blower rotor lobes for smoothness. Inspect rotor shaft serrations and bearing surfaces for wear or burrs.

Check the finished faces of the end plates to see that they are smooth and flat.

Check the finished ends of the blower housing, which receive the end plates, to see that they are flat and free from burrs. The end plates must set flat against the blower housing.

Check blower timing gears for wear or damage. If either timing gear is worn or damaged sufficiently to require replacement, both gears must be replaced as a set.

Inspect the inside of the housing to see that the surfaces are smooth. The blower drive shaft should be straight and true. Shaft serrations should be clean and straight.

Replace all worn or excessively damaged blower parts.

Blower Reassembly

With all blower parts cleaned and inspected, the blower may be reassembled in the prescribed manner as outlined in the manufacturer's maintenance and service manual.

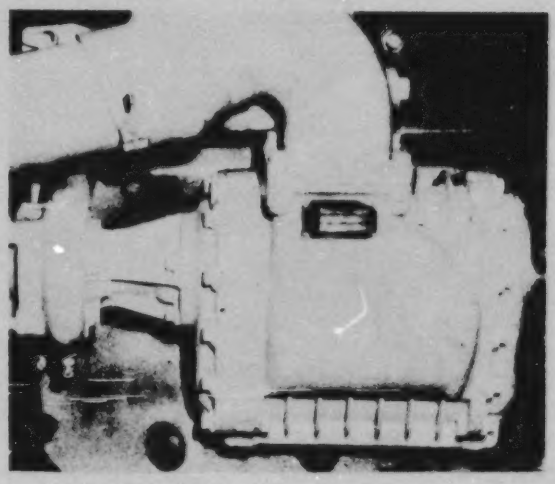

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Figure 7-21. — Supercharger.

SUPERCHARGER

A diesel engine is usually equipped with a supercharger (see fig. 7-21) which is a gear-driven air pump that employs rotors to force air into the engine cylinders. The supercharger must be maintained periodically.

Remove the supercharger's outlet connection and visually check the ends of the rotors and case for evidence of oil leaking from the supercharger seals. Rotors will always show some oil from the vapor tube which is connected to a rocker housing cover. However, only the appearance of "wet" oil at the ends of the rotors would be cause for changing supercharger seals. Be sure to check the lubricating oil lines and connections for any leaks and correct if needed.

Removal

When it is determined that the supercharger must be removed from the engine, follow the procedures given in the manufacturer's service manual.

Disassembly

If it becomes necessary to disassemble the supercharger, be careful when you remove the

intake and discharge connections. Be sure to cover both openings. Wash the exterior of the supercharger with mineral spirits so that no damage is done to its finished surfaces which are usually made from aluminum.

Use the service tool kit furnished and follow recommended disassembly procedures as given in the manufacturer's maintenance and service manual.

Cleaning and Inspection

As the supercharger parts are disassembled, clean them and dry thoroughly with filtered compressed air. Be sure to discard all used gaskets, oil seals, recessed washers, roller bearings, and ball bearings, and replace with new ones.

Inspect the rotors, housing, and end plates for cracks, abrasions, wear spots, and build-up of foreign material. Smooth all worn spots found with a fine emery cloth. Discard cracked, broken, or damaged parts. Remember, rotors and shafts are not separable and must be replaced as a matched set or unit.

Inspect the drive coupling for worn pins, distorted or displaced rubber bushings, and damaged or worn internal splines. Examine the hub surface under the oil seal and replace the coupling if its surface is grooved or worn.

Check the gear fit on the rotor shafts, and the gear teeth for evidence of chatter and wear. Replace the rotors and gears if not within the required tolerances.

Inspect all dowels, oil plungers, piston ring seals, and gasket surfaces. Replace as necessary.

Reassembly

After you have completed the inspection, cleaning, and replacement of worn or damaged parts, the supercharger is reassembled in the manner prescribed by the manufacturer's maintenance and repair manuals.

Upon complete reassembly, and after the supercharger is installed on the engine, add one quart of recommended engine lubricating oil to the gear end plate through the pipe plug hole.

TURBOCHARGER

The turbocharger (see fig. 7-22) is a unit driven by exhaust gas to force (charge) air into the diesel engine cylinders for more complete burning of fuel. As with any air induction component, the turbocharger is subject to environmental situations which could result in a turbocharger failure.

The real problem lies not in fixing the failure, but in determining the cause. Replacing a failed turbocharger without first determining the cause will, more often than not, result in a repeat failure.

The things which can cause a turbocharger to fail are many and varied, but they can be grouped into the following categories:

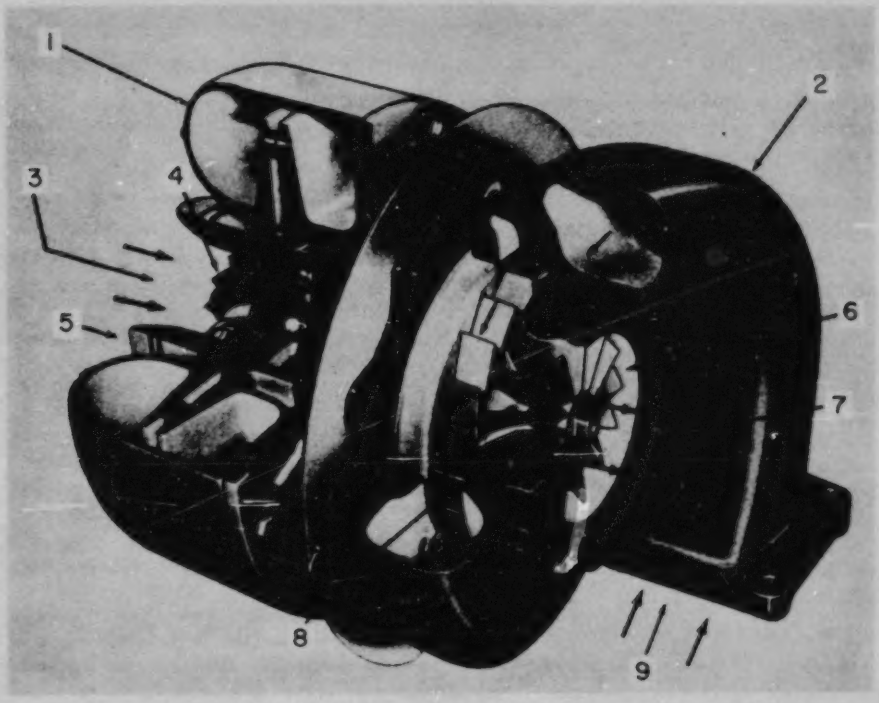
1. Lack of lubricating oil.
2. Foreign material or dirt in the lubricating system.
3. Foreign material in either the exhaust or air induction system.
4. Material or workmanship.

A failure can occur if the lubricating oil being supplied to the turbocharger is not sufficient to (1) lubricate the thrust and journal bearings, (2) stabilize the journal bearings and shaft, and (3) provide the necessary cooling for the bearing and journal surfaces, even for periods as short as five seconds.

Operating the engine with contaminated oil, under the assumption that the oil filter will remove the contaminants before they reach the bearings of the turbocharger, can be quite costly. Actually, there are certain conditions under which the oil filter is bypassed and, if the oil is contaminated, turbocharger damage can result. Some examples of instances where the filter will be by-passed are:

1. The turbocharger lubrication valve is open as it is when starting.
2. The oil filter is clogged and the by-pass valve is open.
3. A lubrication valve or filter by-pass valve malfunctions as a result of worn or binding components.

Contaminated oil will actually cause damage to the turbocharger bearings when this oil is



1. Compressor Cover
2. Turbine Housing
3. Air Inlet Opening
4. Impeller
5. Compressor Extension
6. Turbine Wheel
7. Exhaust Outlet
8. Nozzle
9. Exhaust Inlet Opening

81.367

Figure 7-22. — Turbocharger (cutaway view).

permitted to enter in an amount sufficient to wear out the turbocharger bearings or when the contaminating particles are large enough to plug the internal oil passages and starve the turbocharger for oil.

Because of extremely high tip speeds of the turbine and compressor wheels (up to 1,000 miles per hour) any large particles which enter through the inlet or exhaust systems can mechanically damage the rotating parts of the turbocharger. This is one of the reasons why proper maintenance of the air cleaner is extremely important; also, why thorough cleaning of the inlet and exhaust systems is essential if there has been a previous turbocharger failure, valve failure, or other failure which could leave foreign particles in the engine.

Material or workmanship failure is self-explanatory, that is, either some component of the turbocharger was faulty or its parts were not assembled right.

Removal

The removal of the turbocharger from the engine is not a complicated task when following the procedures set forth by the manufacturer.

Disassembly and Cleaning

After removal of the turbocharger from the engine, make sure the exterior of the turbocharger is cleaned of all loose dirt before disassembly to prevent unnecessary scoring of the rotor shaft. Disassemble in accordance with manufacturer's maintenance and repair manual.

The turbocharger parts accumulate hard, glazed carbon deposits that are difficult to remove with ordinary solvents. This is especially true of the turbine wheel and shaft, diffuser plate, and the nozzle ring and inner heat shield. The cleaner must be capable of removing these stubborn deposits without attacking the metal. All parts should be cleaned as follows:

1. Place all parts in a divided wire basket so parts will not be damaged through contact with each other. Do not pile in the basket. Avoid mutilating precision ground surfaces.

2. Immerse the parts in mineral spirits or similar solvent.

CAUTION: Never use a caustic solution or any type solvent that may attack aluminum or nonferrous alloys.

3. Allow the parts to soak as needed to remove the carbon. A soft bristle brush may be used, if necessary, to remove heavy deposits. Never use wire or other type brushes with stiff bristles.

4. With the oil orifice plug removed, flush out the oil passages in the main casing from the bearing end to remove dirt loosened by the soaking.

5. Remove the parts from the tank. Drain and steam clean thoroughly to remove all carbon and grease. Apply steam liberally to the oil passages in the main casing.

6. Blow off excess water and dry all parts with filtered compressed air.

7. Place parts carefully in a clean basket to avoid damage prior to inspection and reassembly.

Parts Inspection

Inspect all turbocharger parts carefully before reusing. All parts found to be within manufacturer's recommended specifications can be used safely for another service period. Damage to the floating bearing may require replacement of the turbocharger main casing with a new part or an exchange main casing.

Inspect the turbine casing. If you find cracks which are too wide for welding, replace the casing.

If the exhaust casing is warped or heavily damaged on the inside surface due to contact with the turbine wheel or a foreign object, or cracked in any way, the casing is unfit for reuse.

Oil seal plates usually do not wear excessively during service and can be reused if they have not been scored by a seizure of the piston ring.

As you inspect the diffuser plates look for contact scoring by the rotor assembly on the back of the diffuser plate or broken vanes which will make the plate unacceptable for reuse.

Inspect the inner heat shield. If distorted, replace it, too.

Dents found on the outer heat shield can usually be removed, allowing for its reuse. However, if this shield is cut or split in the bolt circle area, it must be replaced.

Inspect the nozzle rings closely for cracks. If cracked, or if the vanes are bent, damaged, or burnt thin, do not reuse.

If signs of wear or distortion are noted during the inspection of the piston ring seals, discard and replace with new ring seals.

Inspect the turbocharger main casing for cracks in the oil passages, capscrew bosses, etc. Also, check the casing for bearing bore wear. If it exceeds the limits allowed by the manufacturer, the bearing bore may be reworked to permit oversize, outer diameter bearings.

Check the oil orifice plug for stripped or distorted threads. Install a new plug if necessary.

The rotor assembly, which consists of a turbine wheel and shaft, sleeve, compressor wheel, thrust washer, and locknut, is an accurately balanced assembly; therefore, if any one of the above parts is replaced as a result of your inspection, the assembly must be rebalanced in accordance with the manufacturer's specifications.

When inspecting the semifloating bearing, be sure to measure both outside and inside diameters of the bearing. If either diameter is worn beyond limits allowed by the manufacturer, the bearing must be replaced.

The front covers that are found to be deeply scored from contact with the compressor wheel cannot be reused. Slight scratches or nicks only can be smoothed out with a fine emery

cloth and the covers reused. Cracked covers, however, cannot be reused and must be replaced with new ones.

All capscrews, lockwashers, and plain washers should be cleaned and reused unless they are found to be damaged beyond reuse.

Reassembly

After inspection of the turbocharger component parts and replacement of parts found damaged or worn, the turbocharger can be reassembled in the manner prescribed by the manufacturer's maintenance and repair manuals.

Be sure to close off all openings in the turbocharger immediately after reassembly to keep out abrasive material prior to mounting on the engine.

Installation

Turbochargers can be mounted on the engine in many different positions. The basic rule to remember is to always locate the oil outlet at least 45 degrees below the turbocharger horizontal centerline when the unit is in the operating position.

CHAPTER 8

VEHICLE SAFETY INSPECTIONS

Preventive maintenance and safety inspection of a vehicle go hand-in-hand. Besides keeping a vehicle in good operating condition, preventive maintenance should help ensure that a vehicle is safe to operate. Proper inspection of the devices or parts of a vehicle that make for safe operation can be carried out at the same time as regularly scheduled preventive maintenance service.

As a CM1 or CMC, you may be assigned the job of vehicle inspector. Besides making scheduled safety inspections, you should be continually on the lookout for dangerous operating practices and for inoperative devices that make a vehicle unsafe for use. You will need to know the regulations pertaining to safety inspection of automotive equipment and the procedures which pertain to this area of responsibility which can be found in the Naval Construction Force Safety Manual (COMCBPAC/COMCBLANT Instruction 5100.1 series) and the Department of the Navy Safety Precautions for Shore Activities Manual, NAVMAT P-5100. Ensure that mechanics under your supervision who perform vehicle inspections are fully aware of what a thorough vehicle inspection consists of. The job of vehicle inspector is not one to be assigned to an inexperienced mechanic.

Like preventive maintenance inspections, safety inspections are very important. As you may know, the condition of an engine is seldom considered in the safety inspection. This inspection concerns items such as lights, brakes, tires, and steering mechanisms. Ensure that your mechanics are fully aware of the great importance, when working on vehicles, of being constantly on the alert to either repair or report any discrepancies that might render the vehicle unsafe to operate.

As a CM1 or CMC, it will normally be your responsibility to ensure that NO vehicle is released from the shop until it is definitely determined that the vehicle is completely safe to operate. Ensure that all personnel under your supervision are fully aware of the danger to life and property in releasing from the shop a piece of equipment that is not fully safe for operation. DO NOT permit anyone to gamble with someone else's life.

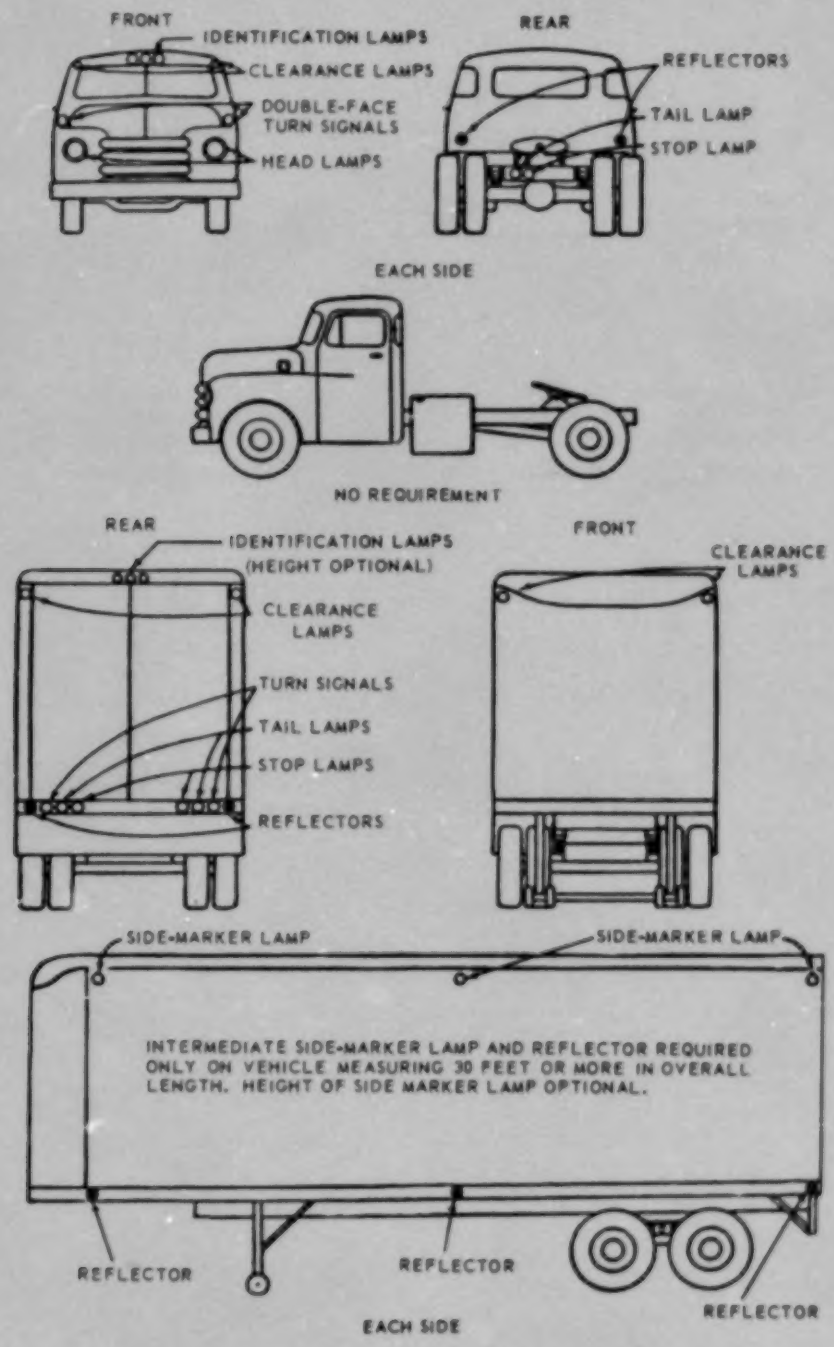
Some of the major items to be checked during a vehicle safety inspection and procedures for making these checks are covered in following sections. To a limited extent, procedures for troubleshooting some of the discrepancies that may be found during a vehicle safety inspection will be discussed.

INSPECTION OF LIGHTING EQUIPMENT

There are many kinds of lights on modern vehicles, each serving a useful purpose. Each light is subjected to periodic inspection. Besides headlights and taillights, there are parking lights, stoplights, and a number of auxiliary lights (such as instrument panel lights and spotlights). Directional signal lights, a requirement for trucks, are also required for passenger cars in most localities. Clearance and identification lights are required for large trucks, buses, and all kinds of trailers. (See fig. 8-1.) Some regulations require that reflectors be mounted on the vehicle as a dual safety precaution in case of light failures. When making a safety inspection, follow the general rule: If a light is on a vehicle, the light must work and meet all safety requirements.

ICC REGULATIONS

Lighting requirements prescribed by the Interstate Commerce Commission (ICC) change frequently. This enables ICC to incorporate the latest developments of lighting and emergency equipment into regulations with a minimum of delay. The list below is merely intended to show the general type of regulations that the ICC prescribes.



2.420

Figure 8-1. — Truck-tractor and semitrailer showing approved lighting equipment.

ICC Equipment Regulations:

HEADLAMPS—Two minimum.

REAR LAMPS—Every bus or truck, every tractor, and every semitrailer or full trailer in excess of 3,000 pounds gross weight: on the rear, one red taillamp, one red or amber stoplight.

Every semitrailer or full trailer weighing 3,000 pounds gross or less: on the rear, one red taillamp, one red or amber stoplight if the semitrailer or full trailer obscures the stoplight on the towing vehicle.

Every pole trailer: on the rear, one red taillamp.

CLEARANCE LAMPS—On every bus or truck 80 inches or more in width and on every semitrailer or full trailer in excess of 3,000 pounds gross weight: on the front, two amber clearance lamps—one at each side; on the rear, two red clearance lamps—one at each side.

On every tractor: on the front, two amber clearance lamps—one at each side.

SIDE MARKER LAMPS—Every bus or truck 80 inches in width and on every semitrailer or full trailer having a gross weight in excess of 3,000 pounds: on each side, one amber side marker lamp located at or near the front, one red side marker lamp located at or near the rear.

On every pole trailer: on each side, one combination marker lamp showing amber to front and red to side and rear.

(Side marker lamps may be combined with clearance lamps.)

REFLECTORS (REAR)—On the rear of every bus or truck, semitrailer or full trailer, two red reflectors, one at each side.

On the rear of every pole trailer, two red reflectors, one at each side, placed to indicate extreme width of the pole trailer or its load, whichever is wider.

One or both of the required red reflectors may be incorporated within the taillamp or taillamps, provided that any such taillamps be located within the height limits specified for reflectors.

REFLECTORS (SIDE)—On every truck or bus 80 inches or more in overall width and on semitrailer or full trailer having a gross weight in excess of 3,000 pounds: one amber reflector on each side, located at or near the front; one red reflector on each side, located at or near the rear.

On every pole trailer: on each side, one red reflector.

FLARES—Three on every bus, truck or tractor. (The use of reflector flares in lieu of electric lanterns or flares (pot torches) permitted on all vehicles.)

HEADLIGHTS

Headlights are tested for intensity, focus, and aim. With the sealed-beam lights used on present day vehicles, the focus is pre-set at the time they are manufactured. Therefore, your main concern will be the aiming and the intensity of the headlights. The aiming of the headlights is accomplished as indicated in figure 8-2. Traffic laws require that headlights be of sufficient intensity to reveal persons and objects for a distance of at least 350 feet ahead. The minimum output established by most States to fulfill this requirement is 5,000 beam candlepower for the upper beam, and 3,500 beam candlepower for the lower beam, on each headlight; for vehicles having two pairs of headlights, these requirements apply to each pair.

Your shop may be provided with an output meter that measures the headlight intensity that can be used in conjunction with a screen for aiming the lights. Or a headlight tester may be available that can be used for aiming the headlight, as well as for measuring the intensity of the light. The headlight tester is preferable,

LOOSEN SCREW TO LOWER BEAM
TIGHTEN SCREW TO RAISE BEAM
TIGHTEN SCREW TO SWING BEAM LEFT
LOOSEN SCREW TO SWING BEAM RIGHT
LOOSEN SCREW TO SWING BEAM LEFT
TIGHTEN SCREW TO SWING BEAM RIGHT

2,124X

Figure 8-2.—Dual sealed beam headlights.

because it does the complete job of checking the headlight without the use of a cumbersome screen.

Headlight testing equipment in the shop should be located so that the equipment can be moved in and out conveniently. A small board and cabinet for tools and equipment used for testing and adjusting headlights should be in the immediate vicinity of the headlight testing area.

Using Screen for Aiming Headlights

Although an output meter may not be available for measuring headlight intensity, you should nevertheless ensure that the headlights of vehicles under your supervision are aimed correctly; a headlight that is not aimed properly may blind drivers of oncoming vehicles. A screen can be made that will enable your men to test headlight aim.

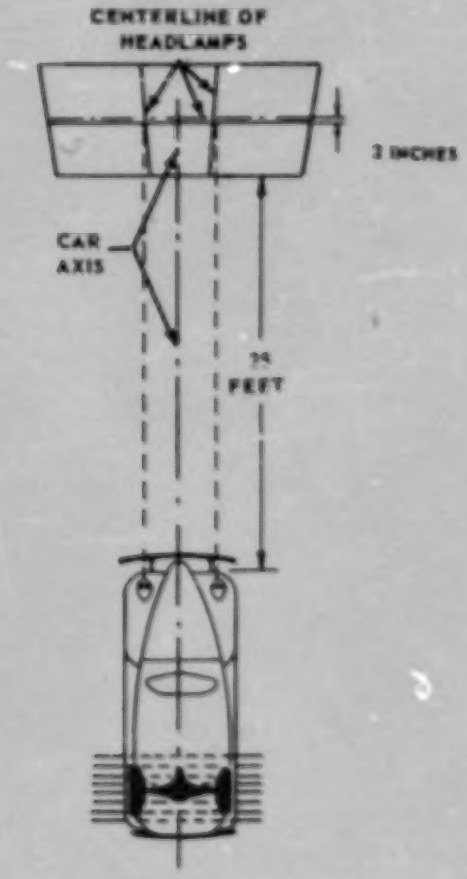


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Figure 8-3. — Screen for checking aim of headlights.

The screen for aiming headlights (fig. 8-3) should be no less than 10 feet wide and 42 inches high. When it is mounted on a frame or easel with casters, the screen should be no more than 12 inches from the floor surface.

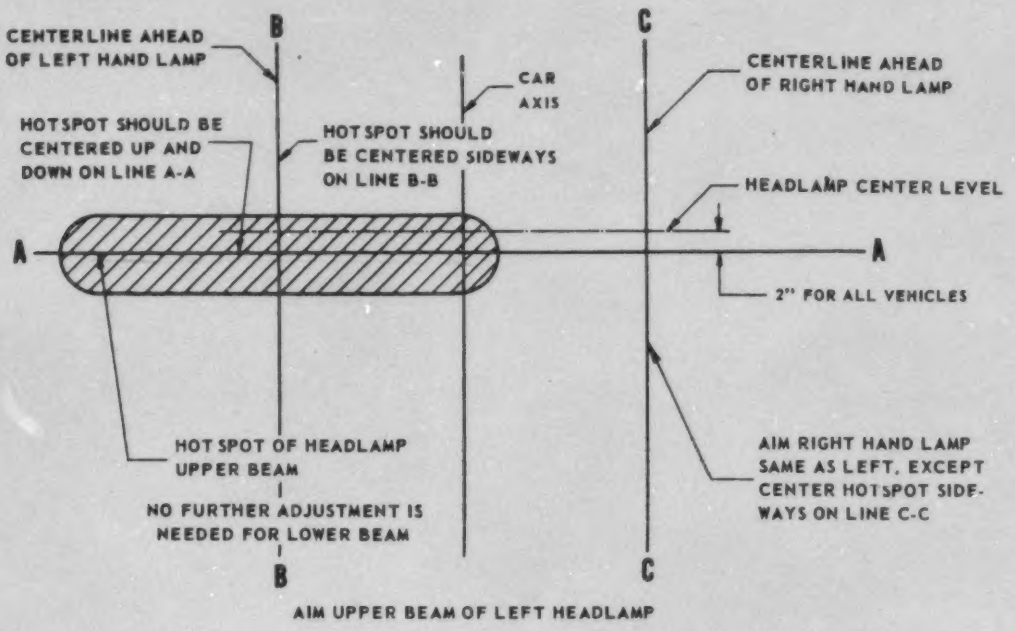
Some screens have both vertical and horizontal reference lines drawn or fixed on the face. A screen of this kind is actually a chart made for aiming lights on a particular vehicle. Such a screen will not work for another vehicle unless the center of the headlight is level with the point where the lines on the screen intersect.

When making a screen it is advisable to put only the headlight center level and vehicle axis lines on it. These lines can accommodate all types of vehicles. By moving the screen (fig. 8-3) up or down, the headlamp level line can be made to conform with the measured height of any headlamp being tested. Moving the vehicle or the screen left or right will accomplish accurate alignment with the vehicle axis line. After these basic steps, vertical lines conforming to the distance between the centers of the headlamps can be added either by line or tape. The vertical lines should intercept the headlamp level line at a point measured from the vehicle axis line exactly one half the distance between the lamp centers.

To comply with regulations of most localities the screen should be placed 25 feet ahead of the headlight. Make sure all tires on the vehicle are properly inflated. The vehicle should have a full tank of fuel (to compensate for weight) and no one other than the operator should be in the vehicle.

Before beginning the actual tests or adjustments, check the regulations for your particular location. Most vehicle inspection regulations contain, in addition to specific instructions for making the tests, illustrations of proper light patterns, and suggestions for inspecting parts of the headlight assembly. Points of adjustment for aiming headlights may differ for various makes of vehicles. Check the manufacturer's manual for the particular make and model of vehicle being inspected.

When aiming the headlights of a vehicle using the 7-inch sealed-beam light unit, remember that the pattern of the upper or driving beam is the one that will be aimed. The 7-inch lamp is designed so that when the upper beam is aimed correctly the lower or passing beam will also


CENTERLINE AHEAD OF LEFT HAND LAMP
B
C
CAR AXIS
CENTERLINE AHEAD OF RIGHT HAND LAMP
HOTSPOT SHOULD BE CENTERED UP AND DOWN ON LINE A-A
HOT SPOT SHOULD BE CENTERED SIDEWAYS ON LINE B-B
HEADLAMP CENTER LEVEL
A
A
2" FOR ALL VEHICLES
HOT SPOT OF HEADLAMP UPPER BEAM
NO FURTHER ADJUSTMENT IS NEEDED FOR LOWER BEAM
AIM RIGHT HAND LAMP SAME AS LEFT, EXCEPT CENTER HOTSPOT SIDEWAYS ON LINE C-C
B
C
AIM UPPER BEAM OF LEFT HEADLAMP

2.126

Figure 8-4.—Accepted beam pattern for aiming passenger vehicle headlights.

be aimed correctly. Cover the lamp that is not being aimed so that one beam will not interfere with the other.

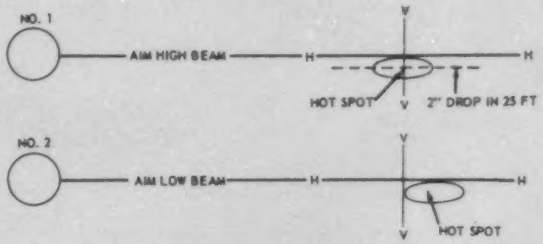
The accepted driving beam pattern for passenger vehicles will show the high-intensity portion (hotspot) of the light rays centered on a horizontal line which is 2 inches below the center or horizontal reference line on the screen. (See fig. 8-4.) This means that there will be a 2 inch drop of the light beam in every 25 feet of longitudinal beam.

Headlights on trucks present a special problem because of the effect of a heavy load. At the same distance of 25 feet, truck headlights should be aimed so that none of the high-intensity portion of the light will project higher than a level of 5 inches below the center of the lamp being tested. This is necessary to compensate for the variations in loading. Bus headlights present a somewhat similar situation except that the effect of a load is usually not quite so great.

Some large equipment will have the lamp centers higher than the testing screen. In this case, place the screen 75 feet ahead of the lights and adjust the horizontal line on the screen to 42 inches; the top of the hotspot of the beam of light should not be above the horizontal line on the screen.

When a 4-headlight system is used the number two lamp will always be mounted on the outboard side of the vehicle.

When using a screen for aiming the headlights on a vehicle that uses the 4-headlight system, adjust the hotspots of the number one (inboard) lamps so that they are centered on the vertical lines 2 inches below the horizontal line. (See fig. 8-5.) The low beams of the number



2.127

Figure 8-5.—Accepted beam pattern for 4-headlight system.

two (outboard) lamps are aimed so that the left edge of the hotspot does not extend to the left of straight ahead or does not extend more than 6 inches to the right or straight ahead. The top of the hotspot of the number two lamp is aimed at the horizontal line as shown in figure 8-5. When the low beams of the number two lamps are properly adjusted, the high beam will be correct.

Using Headlight Tester for Checking Headlights

When using a headlight testing device for checking beam patterns, measuring beam candlepower, and adjusting headlamps, follow the instructions furnished by the manufacturer. Headlight testers differ considerably in design and operating characteristics; therefore, correct instructions for using one tester will not be correct for another. Make sure that all vehicle inspectors know how to use the headlight tester assigned to your shop.

The headlight tester may be one that is permanently mounted on a track or it may be portable. The floor where the tester is used should be reasonably level, and in case there is a slope

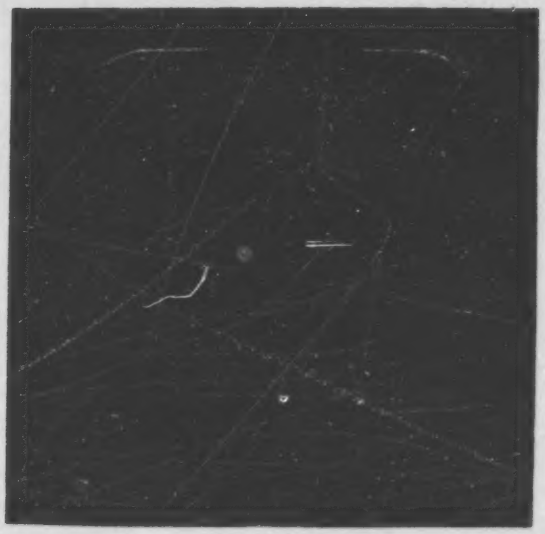


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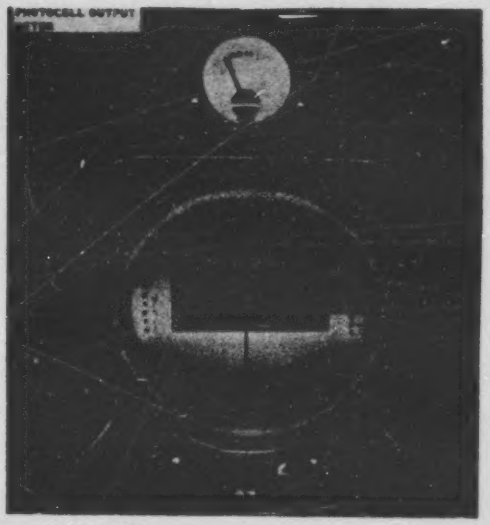
Figure 8-6. — Checking beam pattern with Bear headlight tester.



2.129
Figure 8-7. — Measuring beam candlepower with a Bear tester.

to the floor the tester must be adjusted to this slope. Since the track-type tester will always be used in the same location, it can be adjusted to the slope of the floor when installed. On the portable-type tester, the testing unit must be set to the slope of the floor for each location where it is being used.

Figure 8-6 shows a beam pattern being checked on a Bear headlight tester screen.

Figure 8-7 illustrates the same machine being used to obtain a candlepower reading of the headlamp beam. Notice the image of the photoelectric cell on the screen and the reading on the output meter. To check candlepower in this manner, the operator simply turns the small handle mounted on top of the testing unit to the left until the photocell touches the glass holding the screen. He then raises and lowers the photocell with the same handle until the highest reading is obtained on the output meter. Be sure the hotspot of the light beam is centered on the vertical line before attempting to take a candlepower reading.

If the beams are aimed properly but do not meet the required candlepower, check the wires and connections in the circuit. Poor light from sealed beams is often the result of a loose

connection, bad ground, or use of undersized wire. Any one of these increases the resistance of the circuit. If you can't find a fault in the wiring or connections, replace the sealed-beam unit.

TAILLIGHTS AND STOP LAMPS

All TAILLIGHTS must be of an approved type in accordance with local regulations. Taillights must provide a red indication visible at least 500 feet to the rear of the vehicle. All bulb and lens replacements for them must be of the same type as originally approved. If the vehicle was originally equipped with two rear lamps, both must be present and in good operating condition. If the taillight lens is not red or contains a dot of another color, or if it is cracked, broken, or does not fit tightly, it should be replaced. The taillight should be mounted near the extreme rear of the vehicle. Dump trucks or other especially constructed vehicles may have taillamps mounted other than at the extreme rear, provided the lamp is clearly visible from the rear. Further, a red reflector should be mounted on the extreme rear of the vehicle. The taillights must not be hidden by a bolster or other part of the body or frame. They must be mounted securely to prevent vibration and to make a good electrical contact. The taillights of a vehicle must burn when the headlights are turned on to any position.

A STOP LAMP is usually combined with the taillight by using a double contact, double filament bulb. It may, however, be a separate light. Stop lamps must be adjusted to light up immediately when the brake pedal is depressed; that is, at the beginning of the downward action of the brake pedal. Just as with other lights, bulb and lens replacements for stop lamps must be the same as those originally approved.

LICENSE PLATE LIGHTS

LICENSE PLATE LIGHTS must be bright enough to illuminate the entire license plate so the numbers can be read at a distance of 50 feet to the rear. Most States now require that a separate white light be used to illuminate the license plate; license plates on some older vehicles may still be illuminated through a window in the taillight. License plate lights must be wired so they will turn on and off with the same switch as the taillights.

DIRECTIONAL SIGNALS

Any vehicle or combination of vehicles requires directional signal devices when: (a) the distance from the center of the steering column to the left lateral extension of the body, or load thereon, exceeds 24 inches; or (b) the distance from the top center of the steering column to the extreme rear end of the vehicle or combination of vehicles or their loads exceeds 14 feet.

Most localities do not require directional signals on vehicles of less dimensions than described in the preceding paragraph. However, if a vehicle is equipped with directional signals, they must be of an approved type and in good operating condition.

On truck tractors, a double-faced directional signal unit should be mounted on the top crown of each front fender, or if more practical, on each side of the cab or body. In either case, the lights must be visible from a distance of 100 feet in front of, and to the rear of, the vehicle.

Single-faced signal units of the dual-direction indicating type may be mounted on the rear of vehicles less than 80 inches wide, if the double-faced signals on the front of the vehicle are not clearly visible from behind the vehicle at all angles of approach.

Single-signal units are required at the extreme and opposite corners of the rear of all vehicles or combination of vehicles over 80 inches wide. To be visible at the required distance of 100 feet, they should be mounted at a height of not more than 72 inches, nor less than 24 inches from the level of the ground.

On squared-front vehicles such as buses or cab-over-engine trucks without fenders, or vehicles constructed to a width of 96 inches and over, the double-faced directionals required on the front fenders of the vehicles may be omitted and two single-faced signals mounted instead. These signals must, however, be mounted securely elsewhere on the front of the vehicle and be clearly visible 100 feet to the front of the vehicle.

CLEARANCE LAMPS

Besides the conventional headlamps and taillamps, large trucks, buses, semitrailers and

full trailers require clearance lamps, side-marker lamps, and reflectors.

CLEARANCE LAMPS indicate the extreme width of the vehicle—not necessarily its height as the word "clearance" ordinarily implies. It is the protruding unlighted front and rear corners of the vehicle which are subject to collision with other vehicles or persons, not the top of the vehicle. Therefore, clearance lamps should be mounted at a height best suited to this purpose, and where they can be readily seen at a distance of at least 500 feet. The clearance lights on the front of the vehicle should be amber, and those facing the rear should be red.

As for using clearance lamps to indicate the height of the vehicle, some State regulations require that large vehicles have "identification lights" which more or less answer this purpose. For example, Pennsylvania requires that every vehicle, trailer, semitrailer or combination thereof in excess of 80 inches wide and over 30 feet long shall be equipped with three amber lights in front and three red lights to the rear. These lights, in addition to clearance lights, shall be spaced not less than 6 inches nor more than 12 inches apart, and placed along a horizontal line at or near the top of the vehicle.

SIDE MARKER LAMPS are similar to clearance lamps but indicate the full overall length of the vehicle. They of course, are viewed from the side and must be visible for a distance of 500 feet. Side marker lamps mounted near the front of the vehicle, like clearance lights, must be amber and those near the rear must be red.

Some local regulations required REFLECTORS (apart from those used in the lamps) to be mounted on the rear of a vehicle. This is an additional safety precaution in case lights burn out or get broken. When mounting reflectors, make sure they are not more than 42 inches nor less than 24 inches above the ground.

AUXILIARY LIGHTS

Lights that can be turned on or off for the convenience or safety of the driver or passengers are called auxiliary lights. These lights must be wired to be turned on or off independently, and not with the headlights. Any auxiliary light that is mounted on a vehicle must work in order for the vehicle to pass a light inspection.

SPOTLIGHTS are not approved in all areas as permanent vehicle lighting equipment. Laws in some States permit the use of only one. If a spotlight is installed on a vehicle it must meet inspection requirements. Spotlights should never be used as a supplementary light for headlamps.

BACKUP LIGHTS are approved as accessories for many vehicles. They may be mounted singly or as a pair, one on each side. Backup light lenses must be colorless and, when replaced, of the type originally approved. In addition, backup lights must turn off automatically when the vehicle is in a forward motion, or else be provided with a visible or audible signal to let the operator know that they are on. A backup light must be aimed to strike the road not over 25 feet from the rear of the vehicle.

PARKING LAMPS must have amber or white lenses showing to the front of the vehicle, and must turn on and off with the same switch as the taillights.

A vehicle may not have any light showing red to the front, except school buses, fire and police vehicles, ambulances, and wreckers, unless specifically authorized by local regulations or commands.

LICENSE PLATE LIGHTS—All motorized or towed vehicles traveling state highways must display a white light that makes the rear license plate visable for a distance of 50 feet.

DIRECTIONAL SIGNALS—All motorized or towed vehicles after model year 1958 will be equipped with two front turn signals and two rear turn signals to flash simultaneously.

INSPECTING BRAKE SYSTEMS

Frequent brake inspections are necessary to ensure safe operating condition. Brake inspections are not made just to comply with local and State regulations but to ensure safety of men and equipment. Defective brakes are a contributing factor to many accidents that might have been avoided with frequent and thorough brake inspections. These brake inspections will be more frequent when vehicles are being used in sand, mud, or constant fording operations.

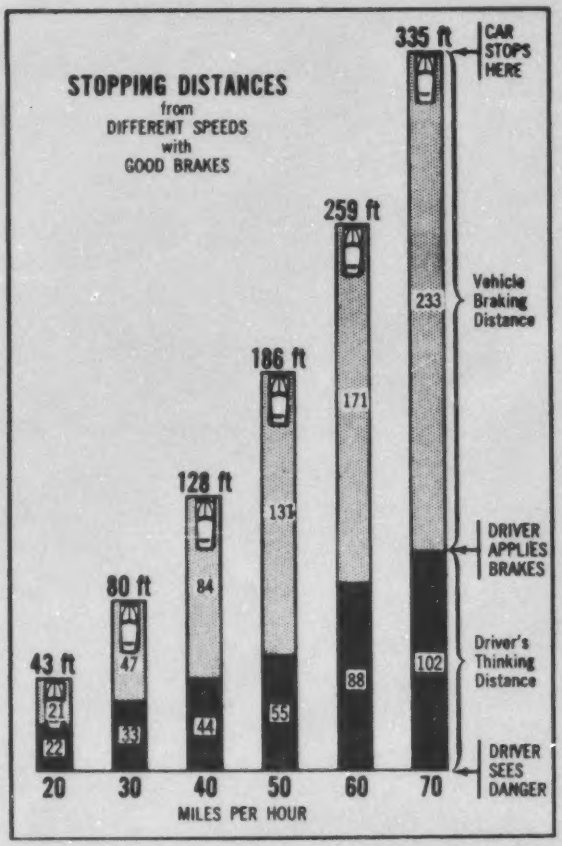


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Figure 8-8.—Stopping distances from different speeds with good brakes.

Regulations for testing and inspecting brakes are about the same in all localities. One requirement is that the brakes must be able to stop the vehicle within a prescribed distance, at a given speed, with a minimum of effort, and without the vehicle's deviating from a straight line.

The stopping requirements for all vehicle brakes are based on the thinking and seeing distance of the operator before brakes are applied. Figure 8-8 illustrates some stopping distances from different speeds with good brakes. These stopping distances have been obtained from taking actual tests.

Brakes can be tested by machines or by actual operation on the road. If a machine is used for testing brakes, a road check should also be made before inspection is finally approved.

Machine testers are suitable in permanent shops. Since these machines are somewhat complicated and require considerable time for setting up, few of them are found at advanced bases. Once the machines are set up, however, they give more accurate indications of brake efficiency than can be obtained from road tests.

As illustrated in figure 8-9, machine testers indicate through tube or dial gages whether the brakes are satisfactory in pounds of braking action at each wheel, and whether brakes need equalizing. Fifty pounds difference in friction braking effort at each wheel is the maximum allowable variation. The amount of braking friction desirable at each wheel depends on the size of the brakes and the vehicle being tested. Instructions for testing are provided with each machine and should be studied by the men making the brake inspections.

All road tests should be made on dry, hard roadway, if possible, and on a comparatively level surface. The surface should be free of loose material.

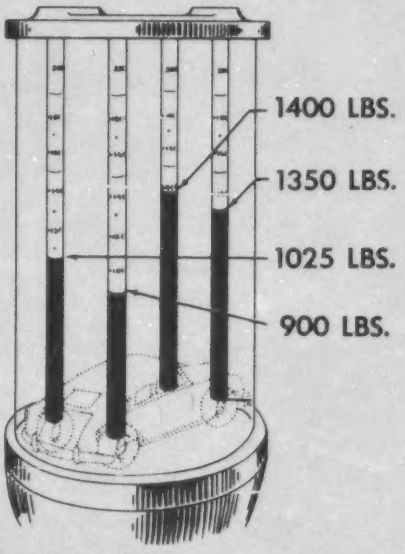

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Figure 8-9.—Columns of liquid indicate 4-wheel brake friction.

Road tests for brakes may be made in several ways. The method commonly used in the SEABEES is to put a line or mark on the roadway at the point the brakes are to be applied. After the vehicle is stopped, usually from a speed of 20 miles per hour, the stopping distance is measured. Be sure the measurement is made from the mark to the FRONT of the vehicle, not the REAR. Inspect the tire marks on the roadway to see if there is an indication of any one wheel braking more than the others. If the brakes do not stop the vehicle within the prescribed distance, are not equalized, grab, or do not hold at all, have the necessary adjustments or repairs made and repeat the test.

All brake systems should be inspected visually from the brake pedal to the brake assembly at the wheel. Make sure that all loose, broken, or missing parts are repaired or replaced. It is important that the movable parts of the system, which have grease fittings, be lubricated — but not overlubricated.

HYDRAULIC

Hydraulic brakes should be inspected for the external condition of the hose and tubings, especially for evidence of leakage or seepage at the couplings. Hose or tubing found to be worn or weakened by rubbing against other parts of the vehicle must be replaced. A point to remember is: never replace steel brake tubing with copper tubing.

Test for leakage by holding the brake pedal depressed for at least 1 minute. If the pedal does not hold, there is a leak somewhere in the system. If there is evidence of a leak, it must be found and repaired, even if it means pulling all wheels to examine the wheel cylinders. After the leak has been repaired, check and replenish the brake fluid in the master cylinder and bleed the brakes.

To comply with all requirements for testing and inspecting brakes, you must see that at least one of the wheels is removed to check the condition of the brake lining and drum. Some manufacturers recommend pulling two wheels — one on each side. Look for loose or broken brakeshoe retracting springs, worn clevis and cotter pins in the brake operating mechanisms, and indications of grease or oil leaks at the wheel bearing grease retainer. Check for leaks of hydraulic fluid at the hydraulic brakeshoe operating cylinder.

Brake linings that pass inspection for wear must be securely fastened to the brakeshoes and free from grease and oil. Small grease or oil spots can be removed from the lining with an non oil base solvent. If the lining is saturated with grease or oil, it should be replaced. Be sure the cause for the grease or oil on the lining is found and remedied.

Badly worn or scored brakedrums should be turned smooth and true on a lathe or replaced. Cracked brakedrums should be replaced, for they may break at any time.

Brakeshoe and drum trouble which is not immediately evident when the wheels are pulled, yet which is proved to be there by road tests, may be caused by the wrong kind of lining, ill-fitting brakeshoes, or brakedrums slightly out-of-round. The clue to these troubles may be chattering, spongy, or grabbing brakes.

Navy vehicles seldom have the wrong kind of brake lining. However, it is possible that a careless mechanic may reverse the primary and secondary shoes on one of the wheels or interchange them between wheels so that the shoes are not exactly mated with the drums against which they expand. If you replace shoes or turn the drum on one side, it must also be done to the opposite side to prevent pull or loss of control.

If you pull one wheel, inspect the brake lining and if you find it in satisfactory condition, it is probable that the other linings are also in satisfactory condition. In that case, you do not need to pull the other wheels. If you find any deficiency in the linings of the wheel that you pull, however, then all the wheels on the vehicle should be pulled and the linings inspected.

The procedures for inspecting and checking the condition of the brake lining and drum given in the preceding paragraphs will also apply when you inspect and check other brake systems.

For other probable causes of trouble (and remedies) in a standard hydraulic brake system, refer to table 8-1.

VACUUM ASSISTED HYDRAULIC BRAKES (POWER)

The same basic inspection procedures given in the hydraulic brake section apply to the vacuum-assisted hydraulic brake system. When checking this system for a source of trouble,

Table 8-1.—Troubleshooting Chart for Hydraulic Brakes (Standard)

MALFUNCTION	PROBABLE CAUSE	POSSIBLE REMEDY
A. Low pedal or pedal goes to toe board.	1. Excessive clearance between linings and drum.	1. Adjust brakes.
	2. Automatic Adjusters not working.	2. Make forward and reverse stops. If pedal stays low, repair faulty adjusters.
	3. Weak brake hose.	3. Replace hose.
	4. Leaking brake pipe.	4. Repair or replace faulty parts.
	5. Leaking wheel cylinder.	5. Clean and rebuild.
	6. Leaking master cylinder.	6. Clean and rebuild.
	7. Leaking master cylinder check valve.	7. Replace valve.
	8. Leaking Stop Light switch.	8. Replace switch.
	9. Air in system.	9. Bleed system.
	10. Plugged master cylinder filler cap.	10. Clean filler cap vent holes, bleed system.
	11. Improper brake fluid.	11. Flush system and replace with correct fluid.
	12. Low fluid level.	12. Fill reservoir, bleed system.
B. Springy, spongy Pedal.	1. Air trapped in hydraulic system.	1. Remove air by bleeding.
	2. Improper brake fluid.	2. Flush and bleed system.
	3. Anchor pin adjustment incorrect.	3. Adjust anchor pin.
	4. Improper lining thickness or location.	4. Install specified lining or replace shoe and lining.
	5. Drums worn too thin.	5. Replace drums.
	6. Master cylinder filler vent clogged.	6. Clean vent or replace cap; bleed brakes.
	7. Weak hose.	7. Replace hose.
C. Excessive pedal pressure required to stop car.	1. Brake adjustment not correct.	1. Adjust brakes or repair self adjuster.
	2. Incorrect lining.	2. Install specified lining.
	3. Grease or fluid soaked lining.	3. Repair grease seal, or wheel cylinder. Install new linings.
	4. Improper fluid.	4. Flush out system, fill with correct type fluid.
	5. Frozen master or wheel cylinder pistons.	5. Rebuild or replace.
	6. Brake pedal binding on shaft.	6. Lubricate or replace.
	7. Linings installed on wrong shoes.	7. Install primary and secondary linings correctly.
	8. Glazed linings.	8. Sand surface of linings.
D. Light pedal pressure - Brakes too severe.	1. Brake adjustment not correct.	1. Adjust the brakes or repair self adjusters.
	2. Loose backing plate on front axle.	2. Tighten plates.

Table 8-1.—Troubleshooting Chart for Hydraulic Brakes (Standard)—continued

MALFUNCTION	PROBABLE CAUSE	POSSIBLE REMEDY
D. Light pedal pressure—Brakes too severe (Cont.).	3. A small amount of grease or fluid on linings.	3. Replace the linings.
	4. Glazed linings.	4. Sand the surfaces of the linings.
	5. Incorrect lining.	5. Install factory specified linings.
	6. Wheel bearings loose.	6. Adjust wheel bearings.
	7. Lining loose on shoe.	7. Replace lining or shoe and lining.
	8. Excessive dust and dirt in drums.	8. Clean and sand drums and linings.
	9. Bad drum.	9. Turn drums in pairs or replace.
E. Brake pedal travel decreasing.	1. Master cylinder compensating port plugged.	1. Open with compressed air or replace.
	2. Swollen cap in master cylinder.	2. Replace rubber parts, flush system.
	3. Master cylinder piston not returning.	3. Rebuild master cylinder.
	4. Weak shoe retracting springs.	4. Replace springs.
	5. Wheel cylinder pistons sticking.	5. Clean cylinder bores and parts. Replace bad parts.
F. Pulsating Brake Pedal.	1. Drums out of round.	1. Refinish drums to specifications.
	2. Loose brake drum on hub.	2. Tighten.
	3. Worn or loose wheel bearings.	3. Replace or adjust.
	4. Bent rear axle.	4. Replace axle.
G. *Brake Fade.	1. Incorrect lining.	1. Replace lining with lining recommended by factory.
	2. Thin drum.	2. Replace drums.
	3. Dragging brakes.	3. Adjust or correct cause.
H. All brakes drag when adjustment is known to be correct.	1. Pedal does not return to stop.	1. Lubricate the pedal.
	2. Improper fluid.	2. Replace rubber parts and refill.
	3. Compensating or bypass part of master cylinder closed.	3. Open with compressed air or replace.
I. One Wheel drags.	1. Weak or broken shoe retracting springs.	1. Replace the defective Brake shoe springs and lubricate the brake shoe ledges.

*Fade is a temporary reduction of brake effectiveness resulting from beat.

Table 8-1.—Troubleshooting Chart for Hydraulic Brakes (Standard)—continued

MALFUNCTION	PROBABLE CAUSE	POSSIBLE REMEDY
I. One Wheel drags. (Cont.).	2. Brake shoe to drum clearance too small or the brake shoe eccentric is not adjusted properly.	2. Adjust.
	3. Loose wheel bearings.	3. Adjust wheel bearings.
	4. Wheel cylinder piston cups swollen and distorted or the piston stuck.	4. Rebuild cylinders.
	5. Pistons sticking in wheel cylinder.	5. Clean or replace pistons; clean cylinder bore.
	6. Drum out-of-round.	6. Grind or turn front or rear drums.
	7. Obstruction in line.	7. Clean out or replace.
	8. Loose anchor pin.	8. Adjust and tighten lock nut.
	9. Distorted shoe.	9. Replace.
	10. Defective lining.	10. Replace with specified lining.
	11. Parking brake cable frozen.	11. Lubricate.
J. Rear brakes drag.	1. Maladjustment.	1. Adjust brake shoes and parking brake mechanism.
	2. Parking brake cables frozen.	2. Lubricate.
K. Vehicle pulls to one side.	1. Grease or fluid soaked lining.	1. Replace with new linings.
	2. Anchor pin adjustment not correct.	2. Major brake adjustment.
	3. Loose wheel bearings; loose backing plate on rear axle or front axle or loose spring bolts.	3. Adjust the wheel bearing; tighten the backing plate on the rear axles and tighten spring bolts.
	4. Linings not of specified kind or primary and secondary shoes reversed.	4. Install specified linings.
	5. Tires not properly inflated or unequal wear of tread. Different tread non-skid design.	5. Inflate the tires to recommended pressures. Rearrange the tires so that a pair of non-skid tread surfaces of similar design, and equal wear will be installed on the front wheels and another pair with the tread will be installed on the rear wheels.
	6. Linings glazed.	6. Sand the surfaces of the linings.

Table 8-1.—Troubleshooting Chart for Hydraulic Brakes (Standard)—continued

MALFUNCTION	PROBABLE CAUSE	POSSIBLE REMEDY
K. Vehicle pulls to one side (Cont.).	7. Water, mud, etc. in brakes.	7. Remove any foreign materials from all of the brake parts and the inside of the drums. Lubricate the shoe ledges and the rear brake cable ramps.
	8. Wheel cylinder sticking.	8. Repair or replace wheel cylinder.
	9. Weak or broken retracting springs.	9. Check springs—replace bent, open-coiled or cracked springs.
	10. Out-of-round drums.	10. Re-surface or replace drums in left and right hand pairs (both front and both rear).
	11. Brake dragging.	11. Check for loose lining. Adjust.
	12. Weak chassis springs, loose "U" bolts, loose steering gear, etc.	12. Replace spring, tighten "U" bolts, adjust steering gear, etc.
	13. Loose steering.	13. Repair and adjust.
	14. Unequal camber.	14. Adjust to spec.
	15. Bad drum.	15. Refinish drums in pairs.
L. One Wheel locks.	1. Gummy lining.	1. Reline.
	2. Tire tread slick.	2. Match up tire tread side to side.
	3. Faulty anchor adjustment.	3. Adjust.
M. Wet Weather, Brakes Grab or won't hold.	1. Linings sensitive to water.	1. Reline.
	2. Dirty brakes.	2. Clean out.
	3. Bent backing plate-opening.	3. Straighten or replace.
	4. Scored drums.	4. Grind or turn in pairs.
N. Brakes Squeak.	1. Backing plate bent or shoes twisted.	1. Straighten or replace damaged parts.
	2. Metallic particles or dust embedded in lining.	2. Sand linings and drums. Remove all particles of metal in surface of linings.
	3. Lining rivets loose or lining not held tightly against the shoe at the ends.	3. Replace rivets and/or tighten lining by rerivetting.
	4. Drums not square or distorted.	4. Turn or grind or replace drums.
	5. Incorrect lining.	5. Replace lining per factory specs.
	6. Shoes scraping on backing plate ledges.	6. Lube ledges. Replace with new shoe and linings, if distorted.

Table 8-1.—Troubleshooting Chart for Hydraulic Brakes (Standard)—continued

MALFUNCTION	PROBABLE CAUSE	POSSIBLE REMEDY
N. Brakes Squeak (Cont.).	7. Weak or broken hold down springs.	7. Replace defective parts.
	8. Loose wheel bearings.	8. Tighten to proper setting.
	9. Loose backing plate, anchor, drum wheel cylinder.	9. Tighten.
	10. Loose shoe links.	10. Tighten.
	11. Linings located wrong on shoes.	11. Install linings correctly.
O. BRAKES Chatter.	1. Incorrect lining to drum clearance.	1. Readjust to recommended clearances.
	2. Loose backing plate.	2. Tighten securely.
	3. Grease, fluid, road dust on lining.	3. Clean or reline.
	4. Weak or broken retractor spring.	4. Replace.
	5. Loose wheel bearing.	5. Readjust.
	6. Drums out-of-round.	6. Grind or turn drums in pairs.
	7. Caulked or distorted shoes.	7. Straighten or replace.
P. Grinding Noise.	1. Shoe hits drum.	1. Switch drums or grind drums.
	2. Foreign material in lining.	2. Remove or replace lining.
	3. Rivets or shoe rubbing drum.	3. Reline—refinish drums.
	4. Rough drum surface.	4. Refinish drums.

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refer to the chart for the standard hydraulic brake system (table 8-1). After the possible causes on this chart have been eliminated, check for causes given in the troubleshooting chart of table 8-2.

NOTE: Make the following test before checking the cause for hard pedal. With the engine stopped, depress the brake pedal several times to eliminate all vacuum from the system. Apply the brakes, and while holding the foot pressure on the brake pedal, start the engine. If the unit is operating correctly, the brake pedal will move forward when the engine vacuum power is added to the pedal pressure. If this test shows that the power unit is not operating, check the probable causes of vacuum failure in table 8-2.

AIR

When a vehicle is equipped with airbrakes, first make a visual inspection of hose lines and tubing to find possible leaks or near leaks from badly worn places. To make an AIR LEAKAGE TEST, start the engine and let it run until the air pressure gage indicates normal operating pressure. With the engine turned off, hold the airbrakes in the maximum applied position and watch the air pressure gage on the dash of the vehicle. The pressure should drop no more than 3 pounds in 1 minute after the brakes are applied and 2 pounds in 1 minute with the brakes released.

An AIR BUILDUP TEST should be made. With the engine stopped, drain all air from the reservoir. Then close all reservoir drain cocks, start the engine, and watch the air pressure gage to see how long it takes to build up to

Table 8-2. — Troubleshooting Chart for Vacuum Assisted Hydraulic Brakes (Power)

MALFUNCTION	PROBABLE CAUSE	POSSIBLE REMEDY
A. *Hard Pedal.	1. Broken or damaged hydraulic brake lines.	1. Inspect and replace as necessary.
	2. Vacuum failure.	2. Check for: a. Faulty vacuum check valve or grommet – replace. b. Collapsed or damaged vacuum hose – replac c. Plugged or loose vacuum fitting – repair. d. Faulty air valve seal or support plate seal – replace. e. Damaged floating control valve – replace. f. Bad stud welds on front or rear housing of power head – replace unless easily repaired.
	3. Defective diaphragm.	3. Replace.
	4. Restricted air filter element.	4. Replace.
	5. Worn or badly distorted reaction disc. (tandem diaphragm).	5. Replace reaction disc.
	6. Cracked or broken power pistons or retainer.	6. Replace power pistons and piston rod retainer.
	7. Incorrect selective reaction piston (tandem diaphragam only).	7. Gauge reaction piston and replace with correct piston.
B. Grabby brakes. (Apparent off and on condition).	1. Broken or damaged hydraulic brake lines.	1. Inspect and replace as necessary.
	2. Insufficient fluid in master cylinder.	2. Fill reservoirs with approved brake fluid and check for leaks.
	3. Defective master cylinder seals.	3. Repair or replace as necessary.
	4. Cracked master cylinder casting.	4. Replace.
	5. Air in hydraulic system.	5. Bleed system.
C. Brakes FAIL to release.	1. Blocked passage in power piston.	1. Inspect and replace as necessary.
	2. Air valve sticking shut.	2. Check for proper lubrication of air valve "O" ring.
	3. Broken piston return spring.	3. Replace.
	4. Broken air valve spring.	4. Replace.
	5. Tight pedal linkage.	5. Repair or replace as necessary.

*Hard pedal is excessive pedal pressure required to apply the brakes.

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Table 8-3. —Troubleshooting Chart for Air Brakes

MALFUNCTION	PROBABLE CAUSE	POSSIBLE REMEDY
A. Low air pressure in system or slow air pressure build-up.	1. Leakage in air system.	1. Check and tighten any loose connecting lines and fittings.
	2. Improperly adjusted compressor governor.	2. Adjust governor.
	3. Loose compressor drive belts.	3. Adjust belt tension.
	4. Worn compressor.	4. Rebuild or replace.
B. Rapid loss of air pressure when engine is stopped.	1. Leakage in air system.	1. Check and tighten any loose connecting lines and fittings.
	2. Leaking compressor discharge valves.	2. Rebuild or replace.
C. Excessive Air Pressure.	1. Improperly adjusted compressor governor.	1. Adjust governor.
	2. Sticking compressor governor plunger.	2. Lubricate governor.
	3. Leaking compressor governor diaphgram.	3. Rebuild or replace.
	4. Restricted air line leading to governor.	4. Replace air line.

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safe operating pressure. If longer than 10 minutes are required to bring the air pressure from 0 to 60 psi, you should have the air compressor and the pressure relief valve checked. With all air pressure exhausted from the air-brake system, start the engine and press the brake pedal to applied position. Observe pressure registered by the dash gage when the stop lamps light. Stop lamps should light before the dash gage registers 10 psi.

Airbrakes on trailers are given an external brake inspection as part of the inspection required on a truck-tractor and trailer combination. They are also tested for holding as if the trailer were suddenly disconnected from the tractor. To make this test, first see that the air lines between tractor and trailer brakes are coupled properly. Then, after starting the engine so both tractor and trailer air reservoirs are charged, quickly and simultaneously disconnect both air line couplings. This having been done, the trailer or semitrailer brakes should be automatically applied. Trailer brakes are designed to stop the trailer when it is accidentally disconnected from the towing vehicle. All states require automatic application of trailer brakes in this emergency. Some states go even further and make special requirements for trailers having a chassis and body weight of 1,000 pounds or over; such trailers must be equipped with adequate brakes which will also hold the vehicle for at least 15 minutes after automatic application.

If these inspections and tests do not disclose the fault, consult the troubleshooting chart of table 8-3.

AIR-OVER-HYDRAULIC

On vehicles equipped with air-over-hydraulic brakes, a good visual inspection should be made of the air compressor, air reservoir, air lines, brake pedal and linkage, the wheel brakes, the master cylinder, and the hydraulic line from the master cylinder to the air-hydraulic power cylinder and from the air-hydraulic power cylinder to the wheel brakes.

Operating troubles resulting from malfunction of the air-over-hydraulic power cylinder are hard pedal (excessive pedal pressure required to apply the brakes) and dragging brakes (power

cylinder fails to return to released position when the brake pedal is released).

To test a sluggish or inoperative power cylinder, first install an air pressure gage in the control valve housing and a hydraulic gage at both the hydraulic fluid inlet line and the hydraulic brake line output port. Then, slowly depress the brake pedal and observe the gages. When the air control pressure gage shows between 1 and 5 psi, the hydraulic pressure at the hydraulic inlet should not exceed 40 psi. Excessive hydraulic pressure indicates a sticking relay piston (caused by swollen or damaged piston sealing cups or a corroded or damaged relay piston sleeve) or sticking control valve poppets (caused by corrosion of the poppets, poppet seats, or damaged poppets).

With the brake pedal fully depressed to the fully applied position, the air control pressure gage should show 90 psi and the hydraulic output pressure gage should show full power (runout) pressure of 1,400 to 1,600 psi. Low pressure or no pressure on the air pressure gage indicates air leakage or an inoperative control valve. Low hydraulic output pressure indicates hydraulic fluid leakage, a sticking hydraulic piston, or an inoperative check valve (in the hydraulic piston) or a residual line check valve.

To test for internal and external air leakage or hydraulic leakage, first depress the brake pedal and apply soapsuds at the air control line and its connections, the double check valve (if so equipped), and at the cylinder body and end plate. Bubbles appearing at any of these points indicate external air leaks. While the pedal is depressed, check for evidence of hydraulic fluid leakage at the outlet fitting cap and around the jamnut on the slave cylinder housing. Internal air leakage is indicated by a pressure drop in excess of 2 psi in 15 seconds which indicates worn or damaged piston packing, a scored cylinder body, or leakage at the poppets in the control valve. Internal hydraulic pressure leakage can also be indicated by hydraulic pressure drop at both hydraulic pressure gages while the brake pedal is depressed.

Dragging brakes can be tested by releasing the brake pedal and observing the air pressure gage and the two hydraulic pressure gages. All gages should register zero without lagging. When pressure is noted at the air pressure gage, a sticking relay piston, damaged or corroded control valve poppet, or a ruptured control valve diaphragm exists. Pressure at the hydraulic pressure gages indicates a sticking hydraulic piston, a sticking power piston, or a weak or broken piston return spring. If the hydraulic pressure gages show a slow pressure drop, a defective check valve (in the hydraulic piston) or a defective residual line check valve is indicated.

If the tests indicate external air leakage, tighten the control line connections. Replace a damaged control line, control line gasket, or double check valve. Internal air leakages require removal of the unit for replacement of worn or damaged power piston packing or end plate gasket, and repair or replacement of the cylinder body or end plate.

If the tests indicate hydraulic fluid leakage, an inoperative control valve, sticking power piston, relay piston, or hydraulic piston, remove the unit for disassembly and repair or replace worn or damaged parts.

VACUUM-OVER-HYDRAULIC

To check the vacuum brake system, first shut off the engine and apply the brakes several times to bleed all vacuum from the system. This may require as many as 20 or 30 applications on systems equipped with vacuum reservoirs. Spongy or soft action of the brake pedal indicates air in the hydraulic system. If this occurs, the system must be bled.

With the pedal held at the normal braking pressure, start the engine. If the pedal lowers toward the floorboard when the engine starts, the vacuum system is operating properly. If the pedal fails to move, the vacuum system is at fault. Although this usually indicates a faulty vacuum cylinder, the vacuum lines, reservoir, and connections should be checked for leaks first. The applicable instructions manual should be consulted for the replacement and repair of the vacuum power cylinder.

EMERGENCY

Emergency brake inspections should be made just as carefully as those for service brakes. There are actually two types of emergency brakes in use on modern vehicles. An external contracting drive shaft transmission brake and a mechanical linkage rear wheel brake. The parking brake is primarily designed to hold the vehicle after it is stopped. You can also use the parking brake to stop a vehicle in case of an emergency, but it usually is not as efficient as the emergency brake. Because emergency brakes are seldom used except for holding the vehicle when parked, some unthinking inspectors

forget them. Too, in reporting brake troubles, the operator often neglects to include troubles concerning the emergency brake. (For the purpose of this discussion, both types of brakes will be called emergency brakes.)

Safety regulations require that the emergency brake be adequate to stop the vehicle from a speed of 20 mph within a distance of 55 feet. This requirement may vary somewhat in different localities, depending upon state regulations. The emergency brake must hold the vehicle on any grade. This requirement covers both passenger and commercial motor vehicles equipped with either the enclosed-type emergency brake at each rear wheel, or a single emergency brake at the drive shaft.

When testing emergency brakes, do so at the same time you test the service brakes; however, make a separate run in a road test. Pay particular attention to the ratchet and pawl or any other automatic locking device that holds the brake in the applied position to ensure that it is operating properly.

Inspect the condition of emergency brake linings and drums just as you would for service brakes. In addition, when inspecting the drive shaft brake, examine the universal joints and splines for loose bolts and grease leaks. Loose universal joint bolts are not uncommon for vehicles having emergency brakes on the drive shaft. Although most vehicles throw a little grease from the spinning drive shaft, it is important that none of it remain on the emergency brake lining.

ELECTRIC

The present qualifications for advancement require the prospective CM1 to be able to trouble-shoot and recommend corrective action for electric brake systems. Due to the fact that the various manufacturers are not installing electric brakes on the vast majority of their equipment, especially the ones the SEABEES will be required to maintain, the requirement for electric brake knowledge is being dropped and there will not be any examination coverage of the subject.

INSPECTION OF STEERING SYSTEMS

When inspecting the steering system of automotive equipment, start with the tires. A tire with a cut that extends into the cord body or that is worn to the tread wear marker (if so equipped) or is worn smooth so that the cord fabric is showing should be replaced. Examine how the tire treads are wearing. The condition of wear will be useful in determining steering troubles.

Some shops have special equipment for balancing wheels and for checking wheel eccentricity and wobble. The wheels must be removed from the vehicle when using some wheel balancing machines. There are other types of balancing equipment that can be used without taking the wheels from the vehicle.

The preliminary check for proper steering can be made during the road test for brakes. At this time, you can feel if the vehicle steers hard, or has too much play in the steering wheel. Likewise, you can tell by "feel" if the front wheels of the vehicle shimmy, wobble, or have a tendency to wander from a straight course.

Steering troubles, with the exception of free play in the steering mechanism, may also result from improper tire inflation, worn tires, maladjusted brakes, or a combination of all of these faults. No attempt should be made to make steering adjustments until the items just mentioned have been checked and corrected.

Under ordinary conditions, major alignment checks for front wheel camber, caster, and kingpin angle are unnecessary for safety inspections. When there is an indication of front end misalignment such as excessive tire wear or hard steering, major alignment checks should be made. When this is necessary, special equipment must be used. Make sure the manufacturer's detailed instructions are followed when checks and corrections are being made to the front end alignment.

Ordinarily, after making the preliminary steering inspections, the following must be done:

1. Examine the amount of free movement at the rim of the steering wheel, following the specifications recommended by the manufacturer. Remember that proper free movement of the steering wheel will minimize steering system wear.

2. Jack up the front wheels of the vehicle and check for loose, broken, and worn parts, such as wheel bearings, spindles, and bushings. Excessive lateral movement at the top or bottom of the tire indicates looseness. When looseness is apparent, adjust the wheel bearings and recheck the lateral movement to determine whether the wheel bearings are loose, or whether the kingpins or ball joints are worn, following the manufacturer's specifications.

3. Check for wear in the steering linkages, particularly at the tie-rod ends. Also look for broken spring leaves, worn spring shackles, loose spring U-bolts, and worn or loose suspension bolts or bushings. At the same time, check for evidence of inoperative shock absorbers.

4. Finally, check for proper toe-in. You can expect to make changes in the toe-in if adjustments for wear in the steering linkages were necessary.

Many problems can develop on a vehicle which directly affect its steering safety. The experience of a well-qualified inspector is indispensable in quickly identifying a problem and having it corrected. Accurate and timely identification of the problems not only saves maintenance dollars but also puts the vehicle back on the road in a safe condition in a minimum of time. Experience is your best teacher.

INSPECTION OF EXHAUST SYSTEM

When inspecting a vehicle, be sure to examine the condition of its exhaust system. Check to see that all parts of the system are securely attached or supported. Gaskets or packing must not show signs of leakage. Remember that exhaust pipes, mufflers, and tailpipes rust from the inside out. Look for places that are rusted through or on the verge of doing so or are damaged badly enough to obstruct the flow of exhaust gases.

Look closely at the point where a tailpipe discharges the exhaust gases. On vehicles with full bodies, such as sedans, the discharge point must be beyond the rear bumper. On a pickup truck or other short-bodied vehicle, the tailpipe must extend to the rear of the cab and beyond any saddle fuel tanks on the vehicle. Make sure that NO part of the exhaust system is located where it might burn wires, fuel system components, or other combustible parts of the vehicle. Also, that no oil or grease collects on any part of the system.

INSPECTION OF WINDSHIELD WIPERS, GLASS, AND DEFROSTERS

When inspecting windshield wipers, be sure to check the condition of the wiper blades. Check to see whether hardness or dry-rot has set in. If so, have the blades replaced with new ones. Also check the mechanical operation of the wipers to see if they properly move across the operators viewing area.

Window glass in the vehicle must be checked to ensure that the glass affords the operator good vision through each window. Pitted or cracked glass should be replaced.

When inspecting for proper mirror installation, be sure that every bus, truck, or truck-tractor is equipped with two rear-view mirrors, one on each side of the vehicle. Ensure that the mirrors are firmly attached and located so as to give the driver a view of the road to the rear along both sides of the vehicle. On vehicles where only one outside mirror is required, it must be on the driver's side. Such a vehicle should also have an inside rear-view mirror to give the driver a view to the rear.

Vehicles that will operate under frosty, icy, or snowy conditions are usually equipped with an automatic defrosting device. Inspect this device for proper operation. Check the level of the coolant in the radiator, and the radiator and defroster hoses and connections. Make sure the defroster is free of any obstruction which limits its capacity to defrost.

INSPECTION OF SEAT BELTS

Seat belts are a safety requirement of all automotive vehicles and should be inspected at regular intervals. When inspecting seat belts, see that they are not frayed or worn. Ensure that the anchors are secure and tight. Check each belt to make sure it does not rub against any sharp metal part of the seat or vehicle that could result in the belt being cut upon impact. The buckle should be inspected to ensure that the locking device is not worn or bent and that it is in proper working order. Also check for proper operation of the seat belt warning device, when the vehicle is so equipped.

INSPECTION OF INSTRUMENTS, CONTROLS, AND WARNING DEVICES

When inspecting a vehicle, be sure to check all instruments, controls, horns, and warning devices for proper functioning and damage.

The instruments inform you of the approximate speed, engine temperature, oil pressure, rate of charge or discharge of the battery, amount of fuel in the fuel tank, distance traveled, and the operating hours. Should any of these instruments not operate properly, have them repaired or replaced.

Certain controls—throttle, choke, starter, heater, windshield wiper, and others—like the instruments must function or perform the task for which they are provided. When they malfunction or do not properly perform, they too must either be repaired or replaced.

The horn installed on automotive equipment is used as a warning device to pedestrians, workmen, or other vehicles. If the horn does not sound during inspection, have it checked for proper ground and correct voltage. When these have been checked out, but the sound is weak, you can improve the tone and volume of the horn by loosening the adjusting locknut and turning the adjusting nut.

Some manufacturers prefer a warning light system rather than a gage indicator system to indicate an unsafe operating condition. A warning light is usually controlled by a pressure switch, temperature switch, or mechanical linkage. When this light system is on a vehicle you are inspecting, check for proper operation. Have any malfunction corrected and damaged warning lights replaced.

INSPECTION OF FIFTH WHEEL AND TRAILER

When inspecting a truck-tractor and trailer, make sure the truck fifth-wheel rocker plate and bed are in good condition, properly assembled, adequately lubricated, and securely mounted. The coupling device—Kingpin lock should operate freely and properly, lock securely, and not show excessive wear. This type of locking device should open only when the positive release lever is manually or automatically activated. Also, the trailer landing gear assembly must be in good condition, adequately lubricated, and properly mounted.

Inspect trailer springs, suspension hanger mechanisms, tension bar assemblies, and associated parts, such as U-bolts, hangers, and shackles; they must show no signs of fractures or breaks. Also check to see that trailer tires are properly inflated, and free of bruises, breaks, or blisters. Reject, and have replaced, any tire in which a cut or other damage extends to the tire cords, or the tread is worn smooth in the center. Be sure that the tires match on trailers equipped with dual wheels.

CHAPTER 9

POWER TRAINS

In a vehicle the mechanism that transmits the power of the engine to the wheels and accessory equipment is called the power train. In a simple situation, a set of gears or a chain and sprocket could perform this task, but automotive vehicles are not designed for such simple operating conditions. They are designed to have pulling power as well as move at high speeds, to travel in reverse as well as forward, and to operate on rough terrain as well as on smooth roads. To meet these varying demands, a number of units have been added including clutches, transmissions, transfer cases, propeller shafts, universal joints, differentials, and live axles (fig. 9-1).

Even though manufacturers have designed many different units which make up power trains, the basic operating principle involved is the same in each. If you understand the basic principle of operation for one unit it will not be too difficult to become familiar with other units. The procedures for maintenance and repair of the various units of the power train are similiar.

This chapter provides information on the various units and the various indications of abnormal operation so that you will be able to diagnose the problems and prescribe corrective action. The information given here is by no means all-inclusive, but should serve as an aid to a better understanding of the factors which influence the guidelines you will use. To obtain more detailed information on the operation and repair of these units, check the specific manufacturer's manuals.

CLUTCHES

It might be well to review briefly not only the purpose of the clutch but also the various types.

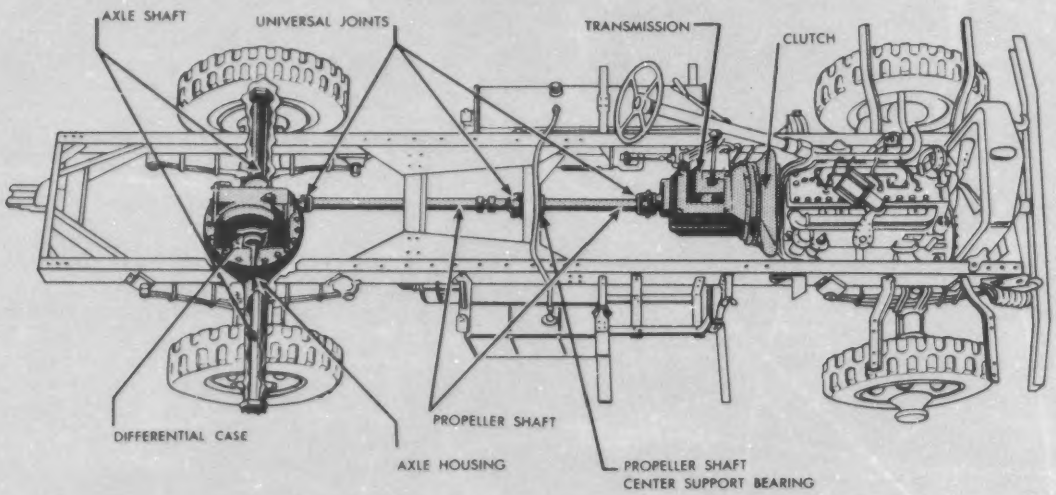

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Figure 9-1.—Type of power transmission system.

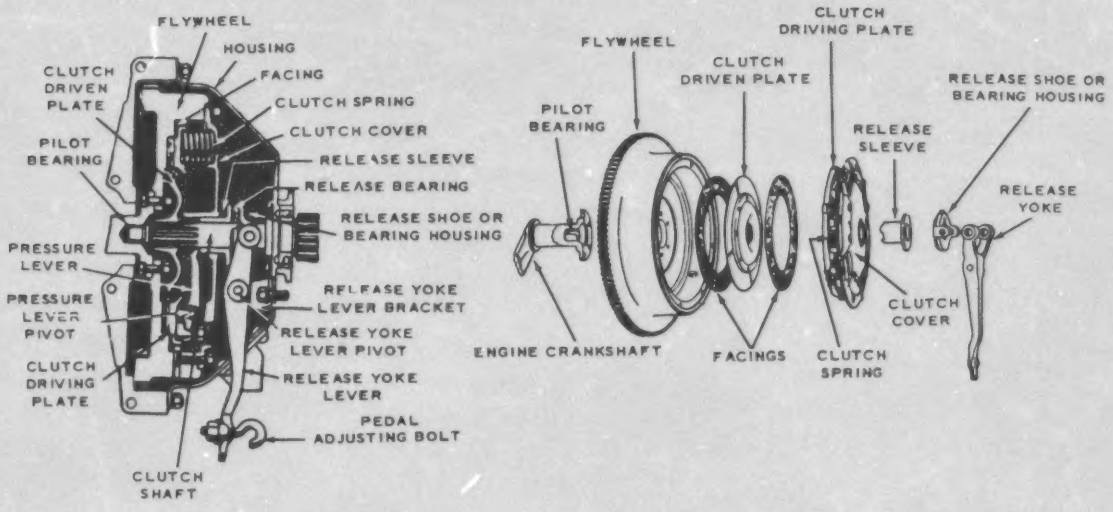

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Figure 9-2.— Exploded and cross-section view of a plate clutch.

As you know, the clutch's purpose is to permit the operator to couple or uncouple the engine and transmission. When the clutch is in the coupling (or normal running) position, power flows through it from the engine to the transmission. If the transmission is in gear, power flows through to the vehicle wheels so that the vehicle moves. Essentially, the clutch has the job of permitting the operator to uncouple the engine temporarily so that the gears can be shifted from one to another forward gear position (or into reverse or neutral). It is necessary to interrupt the flow of power (by uncoupling) before the gears are shifted. Otherwise, gear shifting would be extremely difficult, if not impossible.

The clutch (fig. 9-2) contains a friction disk (or driven plate) about a foot in diameter. It also contains a spring arrangement and a pressure plate for pressing this disk tightly against the smooth rear face of the flywheel. The friction disk is splined to the clutch shaft. The splines consist of two sets of teeth, an internal set on the hub of the friction disk and a matching external set on the clutch shaft. They permit the friction disk to slide back and forth along the shaft but force the disk and the shaft to rotate together.

The flywheel, which is attached to the end of the engine crankshaft, rotates when the engine is running. When the clutch is engaged in the coupling position, the friction disk is held tightly against the flywheel by the clutch springs so that it must rotate with the flywheel. This rotary motion is carried through the friction disk and clutch shaft to the transmission.

To disengage (or uncouple) the clutch, the clutch pedal is pushed down by the operator's foot. This causes the clutch fork to pivot so that the clutch throwout bearing is forced inward. As the throwout bearing moves inward, it operates the release levers. The release levers take up the spring pressure and lift the pressure plate away from the friction disk. The friction disk is no longer pressed against the flywheel face, and the engine can run independently of the power train. Releasing the clutch pedal permits the clutch fork to release the throwout bearing so that the springs once again cause the pressure plate to force the friction disk against the flywheel face. The two again revolve together.

All automotive clutches used with standard transmissions are very similar in construction and operation. There are some differences in the details of the linkages as well as in the pressure-plate assemblies.

There are various types of clutch disks. The type shown in figure 9-2 is known as the plate clutch. The plate clutch is a simple clutch with two plates, and one disk which is clamped between

the two plates. Another type is the single disk clutch. The driving members of the single disk clutch consists of the flywheel and driving (pressure) plate. The driven member consists of a single disk, splined to the clutch shaft and faced on both sides with friction material. When the clutch is fully engaged, the driven disk is firmly clamped between the flywheel and the driving plate by pressure of the clutch springs, forming a direct, nonslipping connection between the driving and driven members of the clutch. In this position, the driven disk rotates the clutch shaft to which it is splined. The clutch shaft is connected to the driving wheels through the transmission, propeller shaft, final drive, differential, and the live axles.

The double disk clutch is substantially the same as the single disk clutch described in the section above except that another driven disk and intermediate driving plate is added.

Other basic information on the elements and operation of the clutch is not included here because it is given in Construction Mechanic 3 & 2, NAVPERS 10644-F. However, information on various indications of abnormal clutch operation is given so that you will be able to diagnose these troubles and prescribe corrective action.

CLUTCH TROUBLESHOOTING

The information given in this section is general and can be applied to nearly every type of clutch that you are likely to encounter. You will probably have special problems for which the solution can be found only by referring to the manufacturer's manual.

Several types of clutch trouble may be encountered. Usually the trouble is fairly obvious. When the malfunction is explained on the Operator's Trouble Report, a quick personal check of the vehicle will generally enable you to correctly diagnose the trouble. It is your responsibility to see that the job is properly performed with a minimum of work. Clutch trouble generally falls into one of six categories:

1. Slipping
2. Chattering or grabbing when engaging
3. Spinning or dragging when disengaging
4. Clutch noises
5. Clutch pedal pulsations, and
6. Rapid disk facing wear.

Slipping Clutches

A clutch that slips when it is engaged is extremely hard on the clutch facings. The facings will wear and burn so badly that the clutch may soon become completely inoperative. Heat from a slipping clutch can soon become great enough to warp the pressure plate and to cause heat checks (small surface cracks) on both the flywheel and pressure plate.

Clutch slippage is particularly noticeable during acceleration, especially from a standing start or in low gear. You can test for clutch slippage by starting the vehicle engine, setting the handbrake, and slowly releasing the clutch pedal while accelerating the engine. If the clutch is in good condition, the engine should stall immediately when the clutch engagement is completed.

There are several conditions that can cause clutch slippage. For instance, the clutch linkage may not be properly adjusted. With an incorrect adjustment that reduces the pedal lash too much, the clutch release bearing will press against the release levers even with a fully released clutch pedal. This prevents full pressure plate engagement, and there will not be enough pressure to hold the friction disk tightly enough against the flywheel. As a result, there is slippage between the surfaces. The way to correct this is to adjust the clutch linkage to give specified clutch pedal lash (free travel).

If the clutch release linkage binds, it may keep the clutch from returning to the fully engaged position. This will cause the clutch to slip. This binding can generally be eliminated by proper lubrication of all points of friction in the linkage. It may be necessary to readjust and realign the clutch operating linkage. If readjustment, lubricating, and freeing of the clutch linkage does not correct the trouble, it may be necessary to remove the clutch for repair. Any of the following conditions within the clutch itself could cause slippage:

1. Weak or broken pressure springs
2. Worn friction disk facings
3. Grease or oil on the disk facings.

Replacing the facings or the complete disk is necessary to remedy condition 2 or 3 listed above.

Incorrectly adjusted release levers (if they are of the adjustable type) may act in the same

manner as incorrectly adjusted clutch linkage or a binding clutch release linkage. In fact, they could prevent full spring pressure on the clutch plate with resulting slippage.

Clutches That Chatter or Grab When Engaging

There are several things that will cause a clutch to chatter or grab when it is being engaged. Loose spring shackles or U-bolts, loose transmission mounting, and worn engine mounts are among the items that must be checked. If the clutch linkage binds, it may release suddenly to throw the clutch into quick engagement, with a resulting heavy jerk. If all these items are checked and found to be in good condition, the trouble is inside the clutch itself and the clutch will have to be removed from the vehicle for repairs.

In the clutch, the trouble could be due to oil or grease on the disk facings or to glazed or loose facings. Binding of the friction disk hub on the clutch shaft could prevent smooth engagement; this condition will require cleaning up of the splines in the disk hub and on the clutch shaft. Broken parts in the clutch, such as broken disk facings, broken cushion springs in the disk, or a broken pressure plate could cause poor clutch action or grabbing.

Clutches That Spin or Drag When Disengaged

The clutch friction disk may spin briefly after the clutch is disengaged. In other words, it takes a moment for the friction disk to come to rest. This normal spinning should not be confused with a dragging clutch. When the clutch drags, the friction disk continues to rotate with and to rub against the flywheel or pressure plate.

When this condition exists, the first thing to check is the pedal-linkage adjustment. If there is excessive free travel of the clutch pedal even full movement of the pedal will fail to force the release bearing in far enough against the release levers to release the clutch fully. If adjustment of the linkage does not correct the trouble, the trouble is in the clutch, and the clutch must be removed, disassembled, and repaired.

When the trouble is found to be in the clutch assembly, you will generally find a warped disk or pressure plate, or the facing on the disk may be loose. On the type of pressure plate assembly with adjustable release levers, improper adjustment of the levers could prevent full disengagement so that the clutch would drag. A friction disk hub that is binding on the clutch shaft can also cause the clutch to drag.

Clutch Noises

When an operator reports that a clutch is making noise, find out whether the noise is heard when the clutch is engaged or when it is disengaged. Clutch noises are usually most noticeable when the engine is idling and the clutch disengaged.

A disk hub that is loose on the clutch shaft will make a noise when the clutch is engaged. This would require replacement of the disk or clutch shaft or perhaps both if both are worn excessively. Friction disk dampener springs that are weak or worn will also cause clutch noises. If the engine and transmission are not properly aligned, the disk hub will move back and forth on the clutch shaft. This will cause the splines of the disk hub and clutch shaft to wear; thus a noisy clutch will soon appear. Any time excessive wear is found on the splines of the disk hub and/or the clutch shaft, always check the transmission and engine alignment.

If clutch noises are noticeable when the clutch is disengaged the trouble will likely be in the clutch release bearing. The bearing is probably either worn, binding, or has lost its lubricant. Most clutch release bearings are factory lubricated; however, on some of the larger trucks and on construction equipment, the clutch release bearing does require lubrication. As a rule, when the release bearing starts making a noise, it must be replaced. If the release levers on the pressure plate assembly are not properly adjusted, they could rub against the disk hub when the clutch is disengaged. If the pilot bearing in the crankshaft is worn or lacks lubricant, it will sometimes produce a high-pitched whine when the transmission is in gear, the clutch is disengaged, and the vehicle is standing still. Under these conditions, the clutch shaft, which is piloted in the bearing in the crankshaft, is stationary, but the crankshaft and bearing are turning.

Clutch Pedal Pulsation

A series of slight movement that can be felt on the clutch pedal or operating lever when the clutch is being disengaged is called clutch-pedal pulsation. These pulsations are noticeable when a slight pressure is applied to the clutch pedal. This is an indication of trouble that could result

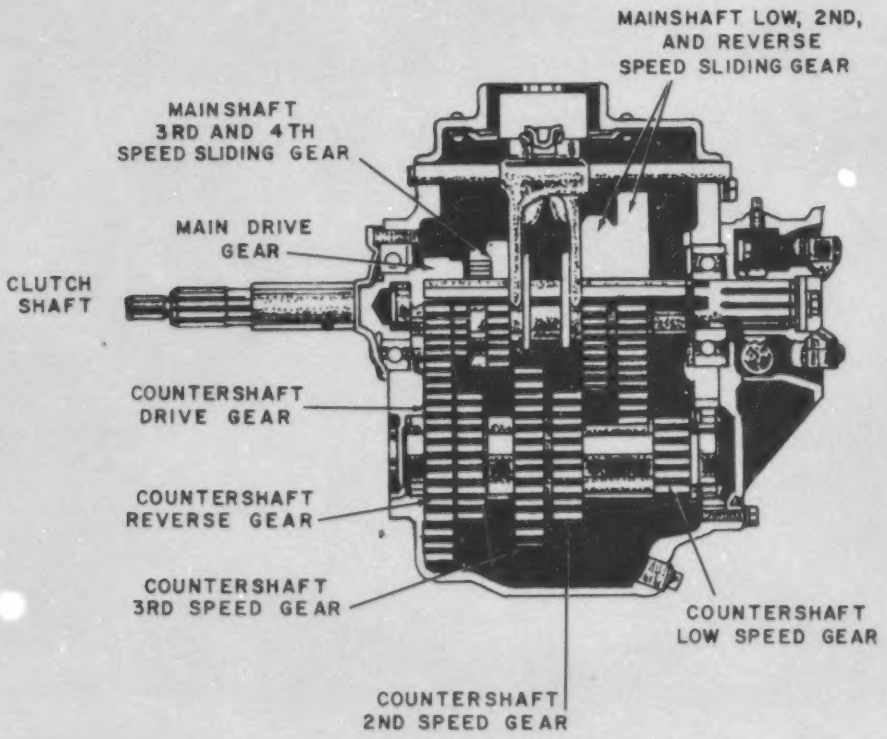
MAINSHAFT LOW, 2ND, AND REVERSE SPEED SLIDING GEAR
MAINSHAFT 3RD AND 4TH SPEED SLIDING GEAR
MAIN DRIVE GEAR
CLUTCH SHAFT
COUNTERSHAFT DRIVE GEAR
COUNTERSHAFT REVERSE GEAR
COUNTERSHAFT 3RD SPEED GEAR
COUNTERSHAFT LOW SPEED GEAR
COUNTERSHAFT 2ND SPEED GEAR

Figure 9-3.—Four-speed truck transmission. 81.181

in serious damage if not corrected immediately. There are several conditions that could exist that would cause these pulsations. One possible cause is misalignment of the engine and transmission.

If the engine and transmission are not in line, detach the transmission and remove the clutch assembly. Check the clutch housing alignment with the engine and crankshaft. At the same time, the flywheel can be checked for wobble since a bent crankshaft flange or a flywheel that is not seated on the crankshaft flange will produce clutch pedal pulsations. If the flywheel does not seat on the crankshaft flange, remove the flywheel; after cleaning the flange and the flywheel, replace the flywheel making sure a positive seat is obtained between the flywheel and crankshaft flange. If the flange is bent at the crankshaft, the crankshaft must be replaced.

Other causes of clutch pedal pulsations include uneven release-lever adjustments, warped pressure plate, or warped clutch disk. If the pressure plate or clutch disk is warped, it should be replaced.

Rapid Clutch Disk Wear

Rapid clutch disk wear will be caused by any condition that permits slippage between the clutch disk facings and the flywheel or pressure plate. An operator may have the habit of "riding" the clutch; this practice can cause slippage. Frequent use of the clutch or slow releasing of the clutch after disengaging will increase clutch facing wear. The remedy here is for the operator to use the clutch properly and only when necessary. Broken or weak pressure springs within the plate assembly will cause slippage. The springs must be replaced to correct this problem. Improper clutch linkage adjustment or binding of the linkage may prevent full spring pressure from being applied to the clutch disk. Any condition that keeps less than full spring pressure from being applied to the clutch disk is apt to cause slipping.

Stiff Clutch Pedal

A stiff clutch pedal, or a pedal that is hard to depress, is likely to result from lack of

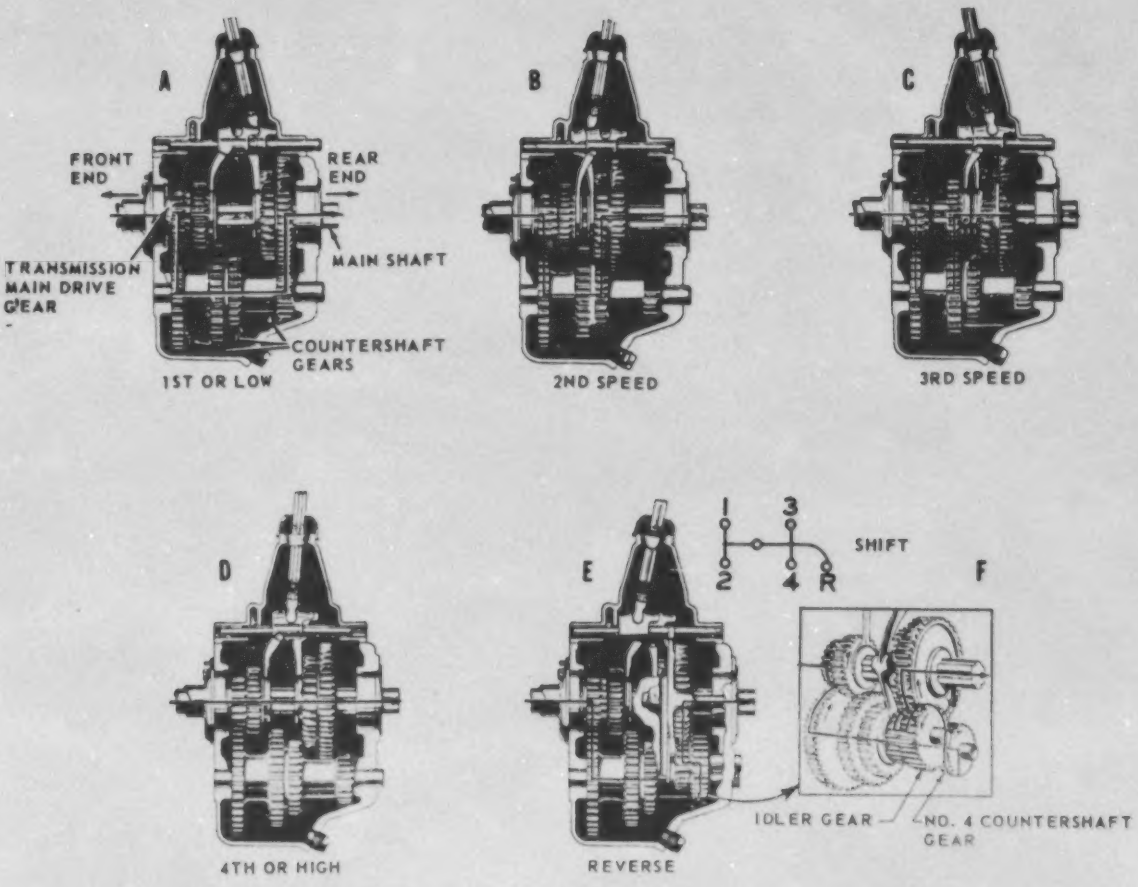

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Figure 9-4.— Power flow through a 4-speed transmission.

lubricant in the clutch linkage, from binding of the clutch-pedal shaft in the floorboard seal, or from misaligned linkage parts that are binding. In addition, the overcenter spring (on vehicles so equipped) may be out of adjustment. Also, the clutch pedal may be bent so that it rubs on the floorboard and is hard to operate. To correct these conditions, parts must be realigned, lubricated, or readjusted as required.

TRANSMISSION

The transmission (fig. 9-3) is part of the power train. It is located in the rear of the engine between the clutch housing and the propeller shaft, as shown in figure 9-1. The transmission transfers engine power from the clutch shaft to the propeller shaft, and allows the driver, or operator to control the power and speed of the vehicle. The transmission shown in figures 9-3 and 9-4 is a sliding gear transmission. Many late model trucks have either constant mesh or synchromesh transmissions (explained later). However, the principles of operation and gear ratios are the same.

The Rate Training Manual Basic Machines, NAVPERS 10624-A discusses gears, and their mechanical advantages, and explains how to compute the speed and reduction ratio of gears in a typical automotive transmission. If you are a little rusty on this point, study the manual

Basic Machines. This manual will help you to understand the transmission and power transfer mechanisms described in this chapter.

FOUR-SPEED TRUCK TRANSMISSION

The gear shift lever positions shown in the small inset in figure 9-4 are typical of most four-speed truck transmissions. The gear shifting lever, shown at A, B, C, D, and E in the illustration, moves the position of the two shifting forks which slide on separate shafts secured in the transmission case cover. Follow the separate diagrams to learn what takes place in shifting from one speed to another. For example, as you move the top of the gear shift lever toward the forward left position, the lower arm of the lever moves in the opposite direction to shift the gears. The fulcrum of this lever is in the transmission cover.

In shifting transmission gears, it is necessary to use the clutch pedal to disengage the clutch. Improper use of the clutch will cause the gears to clash, and may damage them by breaking the gear teeth. A broken tooth or piece of metal can wedge itself between two moving gears and ruin the entire transmission assembly.

When you shift from NEUTRAL to FIRST or LOW speed (A of fig. 9-4), the smallest countershaft gear engages with the largest sliding gear. LOW gear moves the truck at its lowest speed and maximum power. The arrow indicates the flow of power from the clutch shaft to the propeller shaft.

The SECOND speed position is obtained by moving the gear shift lever straight back from the LOW speed position. You have to use the clutch when shifting. In B of figure 9-4, you will see that the next to the smallest countershaft gear is in mesh with the second largest sliding gear. The largest sliding gear (shift gear) has been disengaged. The flow of power has been changed as shown by the arrow. The power transmitted to the wheels in SECOND gear (speed) is less, but the truck will move at a greater speed than it will in LOW gear if the engine speed is kept the same.

In shifting from the SECOND speed to the THIRD speed position, you move the gear shift lever through the neutral position. This is done in all selective gear transmissions. From the NEUTRAL position the driver can select the speed position required to get the power he needs. In C of figure 9-4 you will notice that the gear shift lever is in contact with the other shifting fork, and that the forward slide gear has been meshed with the second countershaft gear. The power flow through the transmission has again been changed, as indicated by the arrow, and the truck will move at an intermediate speed between SECOND and HIGH.

You shift into FOURTH or HIGH speed position by moving the top of the shift lever back and to the right from the NEUTRAL position. In the HIGH speed position, the forward shift or sliding gear is engaged with the constant speed gear as shown in D of figure 9-4. The clutch shaft and the transmission shaft are now locked together and the power flow is in a straight line. In HIGH, the truck propeller shaft revolves at the same speed as the engine crankshaft, or at a 1 to 1 ratio.

You shift to REVERSE by moving the top of the gear shift lever to the FAR right and then to the rear. Most trucks have a trigger arrangement at the gear shift ball to unlock the lever so that it can be moved from neutral to the far right. The lock prevents unintentional shifts into reverse. Never attempt to shift into reverse until the forward motion of the vehicle has been completely stopped.

Here is where your study of the manual Basic Machines will come in handy. Basic Machines informs us that an idler gear is used to reverse direction but has no effect on the gear ratio in a gear train. In F of figure 9-4, you can see how the idler gear fits into the transmission gear train. In E of figure 9-4, you can see what happens when you shift into reverse. An additional shifting fork is contacted by the shift lever in the far right position. When the shift to reverse is completed, this fork moves the idling gear into mesh with the small countershaft gear and the large sliding gear at the same time. The small arrows in the inset show how the engine power flows through the transmission to move the propeller shaft and the wheels in a reverse direction.

The different combination of gears in the transmission case makes it possible to change the vehicle speed while the engine speed remains the same. It is all a matter of gear ratios, having large gears drive small gears, and small gears driving large gears. If a gear with 100

teeth drives a gear with 25 teeth, the small gear will travel four times as fast as the large one. You have stepped up the speed. Now, let the small gear drive the large gear, and the large gear will make one revolution for every four of the small gear. You have reduced speed, and the ratio of gear reduction is 4 to 1.

In the truck transmission just described, the gear reduction in LOW gear is 7 to 1 from the engine to the propeller shaft. In HIGH gear the ratio is 1 to 1, and the propeller shaft turns at the same speed as the engine. This holds true for most all transmissions. The SECOND and THIRD speed positions provide intermediate gear reductions between LOW and HIGH. The gear ratio in SECOND speed is 3.48 to 1, and in THIRD is 1.71 to 1. The gear reduction or gear ratio in reverse is about the same as it is in LOW gear, and the propeller shaft makes one revolution for every seven revolutions of the engine, but in the opposite direction of rotation.

All transmissions do not have four speeds forward, and the gear reductions at the various speeds are not necessarily the same. Passenger cars, for example, usually have only three forward speeds and one reverse speed. Their gear ratios are about 3 to 1 in both low and reverse gear combinations. You must remember, the gear reduction in the transmission is only between the engine and the propeller shaft. Another reduction gear ratio is provided in the rear axle assembly. If you have a common rear axle ratio of about 4 to 1, the gear reduction from the engine of a passenger car to the rear wheels in low gear would be approximately 12 to 1. In high gear, the ratio would be 4 to 1 as there would be no reduction of speed in the transmission.

CONSTANT MESH TRANSMISSION

To eliminate the usual transmission noise developed in the old-type spur-tooth gears used in the sliding gear transmission, the automotive manufacturers developed the constant-mesh transmission which contains helical gears.

In this type of transmission, certain countershaft gears are constantly in mesh with the main shaft gears. The main shaft meshing gears are arranged so that they cannot move endwise. They are supported by roller bearings so that they can rotate independently of the main shaft (figs. 9-5 and 9-6).

In operation, when the shift lever is moved to THIRD, the THIRD and FOURTH shifter fork moves the clutch gear (A, fig. 9-6) toward the THIRD speed gear (D, fig. 9-6). This engages the external teeth of the clutch gear with the internal teeth of the THIRD speed gear. Since the THIRD speed gear is rotating with the rotating countershaft gear, the clutch gear must also rotate. The clutch gear is splined to the main shaft, and therefore, the main shaft rotates with the clutch gear. This principle is carried out when the shift lever moves from one speed to the next.

Constant-mesh gears are seldom used for all speeds. Common practice is to use such gears for the higher gears, with sliding gears for FIRST and REVERSE speeds or for REVERSE only.

SYNCHROMESH TRANSMISSION

The synchromesh transmission is a type of constant-mesh transmission that permits gears to be selected without clashing, by synchronizing the speeds of mating parts before they engage. It employs a combination metal-to-metal friction cone clutch and a dog or gear positive clutch to engage the main drive gear and second speed main-shaft gear with the transmission main shaft. The friction-cone clutch engages first, bringing the driving and driven members to the same speed, after which the dog clutch engages easily without clashing. This process is accomplished in one continuous operation when the driver declutches and moves the control lever in the usual manner. The construction of synchromesh transmission varies somewhat with different manufacturers, but the principle is the same in all.

The construction of a popular synchromesh clutch is shown in figure 9-7. The driving member consists of a sliding gear splined to the transmission main shaft with bronze internal cones on each side. It is surrounded by a sliding sleeve having internal teeth that are meshed with the external teeth of the sliding gear. The sliding sleeve is grooved around the outside to receive the shift fork. Six spring-loaded balls in radially-drilled holes in the gear fit into an internal groove in the sliding sleeve and prevent it from moving endwise relative to the gear

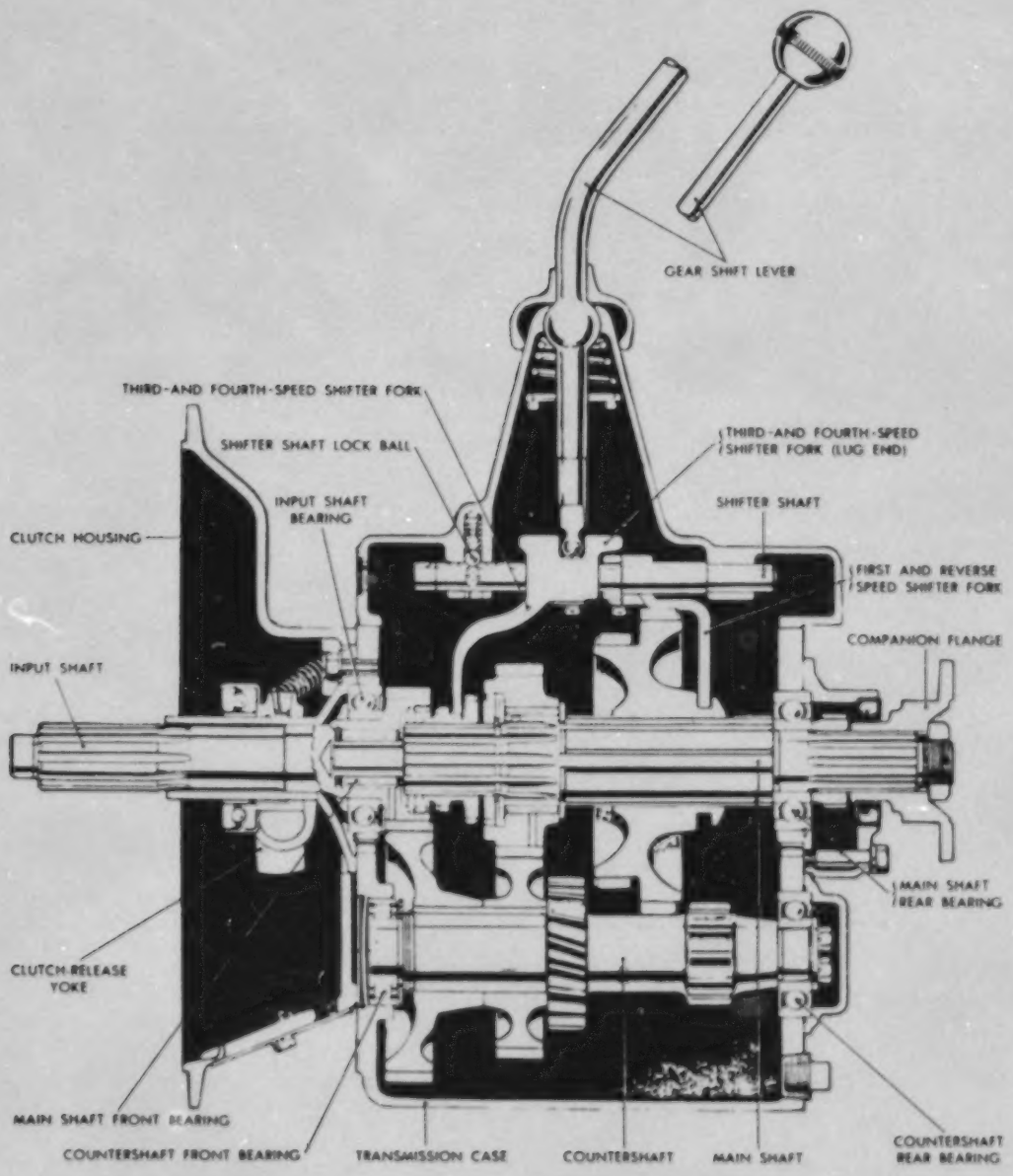

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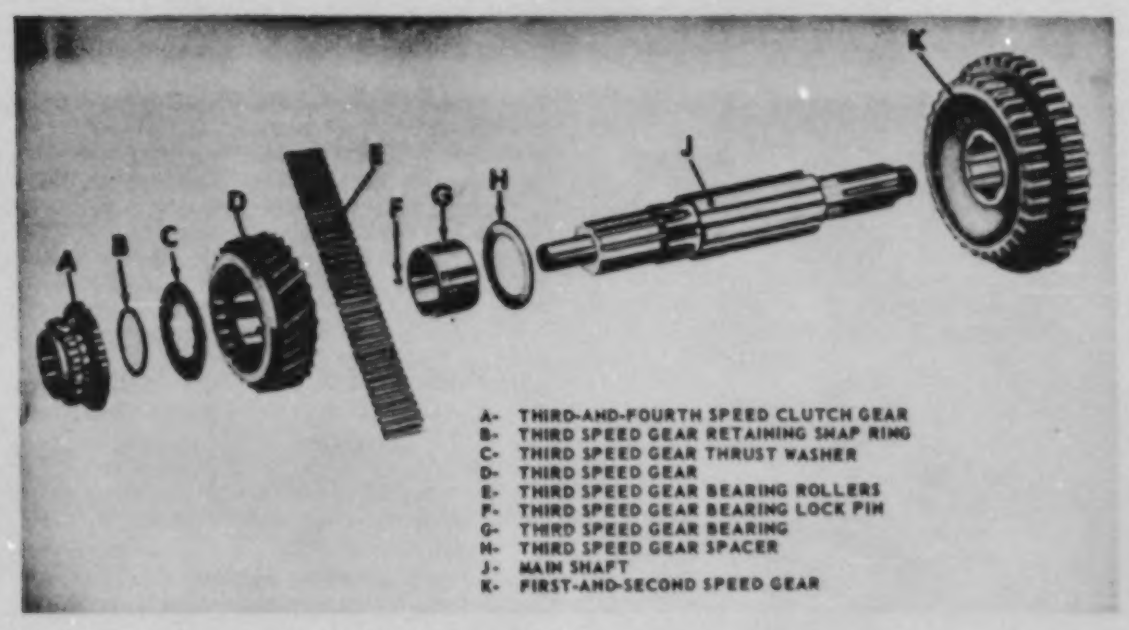
Figure 9-5.—Constant-mesh transmission assembly—sectional view.


A- THIRD-AND-FOURTH SPEED CLUTCH GEAR
B- THIRD SPEED GEAR RETAINING SNAP RING
C- THIRD SPEED GEAR THRUST WASHER
D- THIRD SPEED GEAR
E- THIRD SPEED GEAR BEARING ROLLERS
F- THIRD SPEED GEAR BEARING LOCK PIN
G- THIRD SPEED GEAR BEARING
H- THIRD SPEED GEAR SPACER
J- MAIN SHAFT
K- FIRST-AND-SECOND SPEED GEAR

81.184

Figure 9-6.—Disassembled main shaft assembly.

until the latter has reached the end of its travel. The driven members are the main drive gear and second-speed main shaft gear, each of which has external cones and external teeth machined on its sides to engage the internal cones of the sliding gear and the internal teeth of the sliding sleeve.

The synchromesh clutch operates as follows: when the transmission control lever is moved by the driver to the third-speed or direct-drive position, the shift fork moves the sliding gear and sliding sleeve forward as a unit until the internal cone on the sliding gear engages the external cone on the main drive gear. This action brings the two gears to the same speed and stops endwise travel of the sliding gear. The sliding sleeve then slides over the balls and silently engages the external teeth on the main drive gear, locking the main drive gear and transmission main shaft together as shown in figure 9-7. When the transmission control lever is shifted to the second-speed position, the sliding gear and sleeve move rearward and the same action takes place, locking the transmission main shaft to the second-speed main shaft gear. In the past years it has been the practice of the manufacturers not to use the synchromesh clutch on the first or reverse speeds. However, it is becoming common practice on many late model vehicles to use synchromesh clutches on first speed. On transmissions of the type that do not use synchromesh clutches on first and reverse speeds, the first speed is engaged by an ordinary dog clutch when constant mesh is employed, or by a sliding gear; reverse is always engaged by means of a sliding gear. Figure 9-8 shows a synchromesh transmission in cross section which uses constant-mesh helical gears for the three forward speeds and a sliding spur gear for reverse.

Some transmissions are controlled by a steering-column control lever (fig. 9-9). The positions for the various speeds are the same as those for the vertical control lever except that the lever is horizontal. The shifter forks are pivoted on bellcranks which are turned by a steering column control lever through the linkage shown. The poppets shown in figure 9-8 engage notches at the inner end of each bell crank.

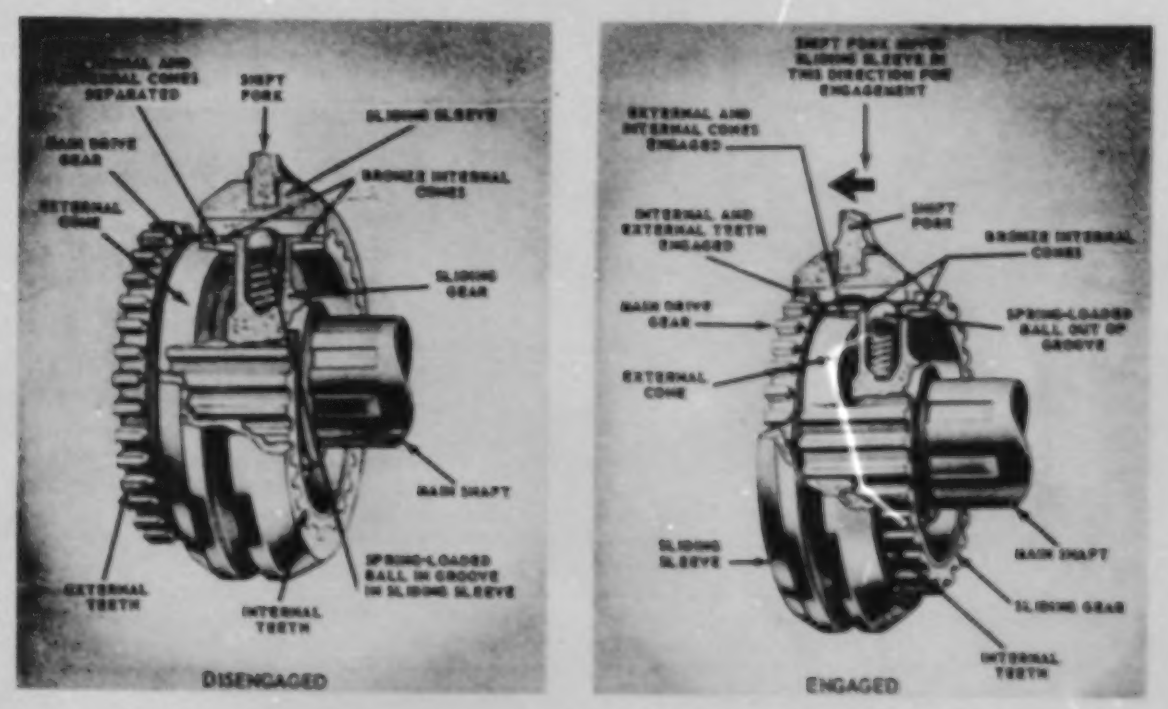


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Figure 9-7. — Synchromesh clutch-disengaged and engaged.

Other types of synchromesh transmissions controlled by steering column levers have shifter shafts and forks moved by a linkage similar to those used with a vertical control lever.

AUXILIARY TRANSMISSION

Auxiliary transmissions are mechanisms mounted in the rear of the regular transmission to provide an increased number of gear ratios. The types most commonly used, normally have only a low and a high (direct) range, incorporated into a transfer assembly. The low range provides an extremely low gear ratio on hard pulls. At all other times the high range is used, the power merely passing through the main shaft. Gears are shifted by a separate gearshift lever in the driver's cab. (See fig. 9-10.)

Trucks require a greater engine-to-axle gear ratio than passenger cars, particularly when manufacturers put the same engine in both types of equipment. In a truck, the auxiliary transmission increases the mechanical advantage. It is connected to the rear of the main transmission by a short propeller shaft and universal joint. Its weight is supported on a frame cross-member as shown in figure 9-10. This illustration also shows how the shifting lever would extend into the driver's compartment near the lever operating the main transmission.

In appearance and in operation, auxiliary transmissions are similar to main transmissions, except that some may have two and some, three speeds (low direct and overdrive). When an auxiliary transmission, like the one shown in figure 9-11, is in the DIRECT SPEED position, power is transmitted directly through the auxiliary transmission to the propeller shaft, and the FORWARD and REVERSE speeds on the main transmission are the same. When the auxiliary transmission is shifted into LOW

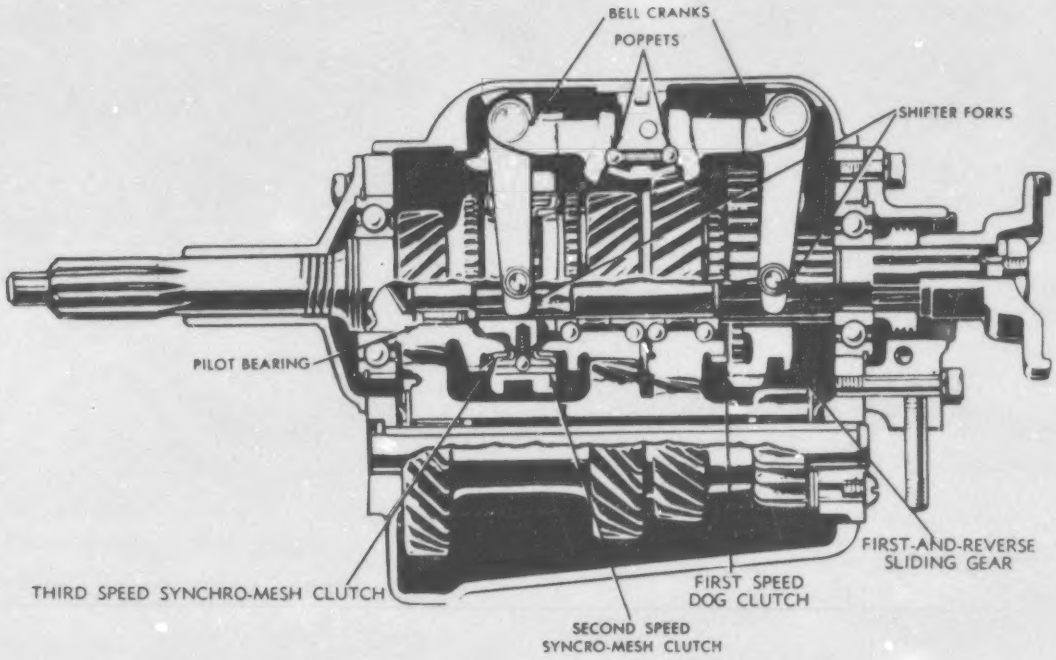

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Figure 9-8. — Synchromesh transmission arranged for steering column control.

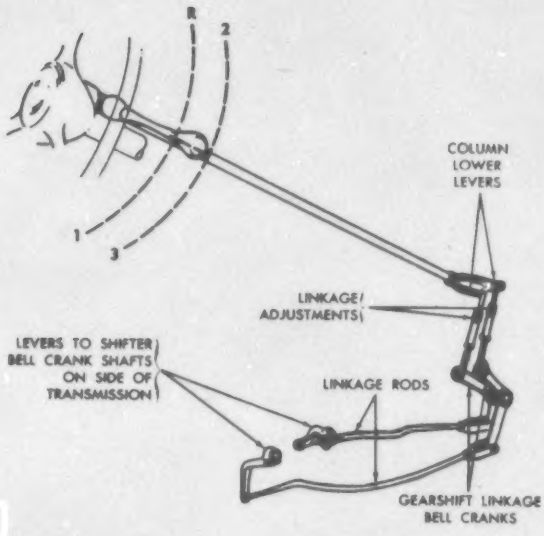

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Figure 9-9. — Steering column transmission control lever and linkage.

SPEED, it reduces each speed of the main transmission. You can see that when the low speed of the auxiliary transmission is used with the lowest speed of the main transmission, it causes the engine to drive the wheels very slowly and with less engine horsepower.

The constant mesh type of auxiliary transmission illustrated in figure 9-11 has two gear combinations. The main drive gear is part of the input shaft, and it is in constant mesh with the countershaft drive gear. A pilot bearing aligns the main shaft with the drive shaft. The low speed main shaft gear runs free on the main shaft when direct drive is being used and is in constant mesh with the countershaft low speed gear. A gear-type dog clutch, splined to the main shaft, slides forward or backward when you shift the auxiliary transmission into high or low gear position.

In HIGH GEAR, when direct drive from the main transmission is being used, the dog clutch is forward and makes a direct connection between the input shaft and the main shaft as shown in

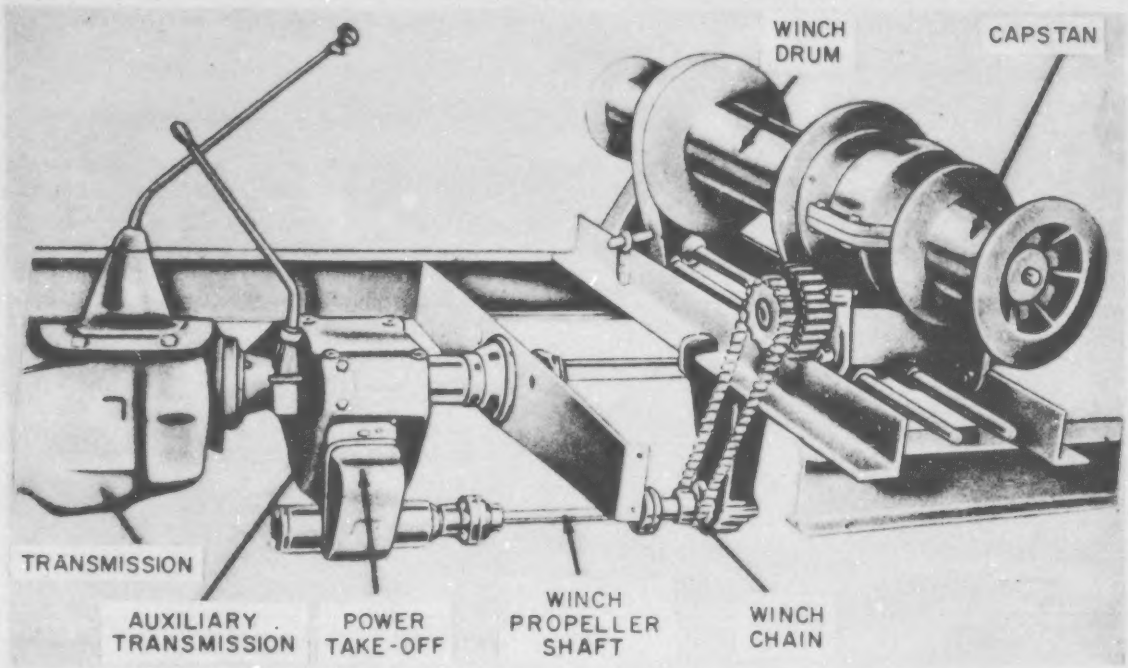

Figure 9-10.—Auxiliary transmission power take-off driving winch. 81.188

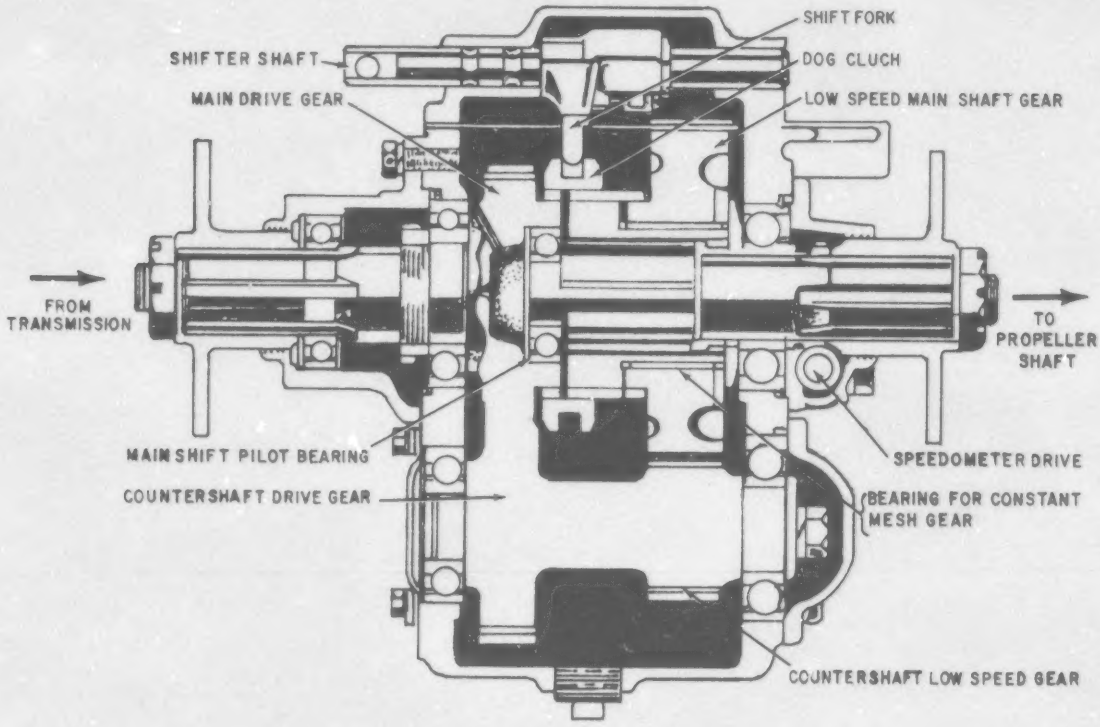

Figure 9-11.—Sectional view of auxiliary transmission showing gear arrangement. 81.189

the illustration. When in LOW GEAR, the dog clutch is meshed with the low-speed main-shaft gear and is disengaged from the main-drive gear.

TRANSMISSION TROUBLE-SHOOTING

As a first step in transmission service, diagnosis of the trouble should be made to pinpoint the malfunction in the unit. It is not always possible to determine the exact location of the trouble and the unit must be removed from the vehicle so that it can be torn down and examined. As a first class or chief it will be your responsibility to make the final diagnosis as to the nature of the trouble. Many times an operator will report transmission noise on the Operator's Trouble Report when, in fact, the noise may be coming from some other component of the vehicle's power train.

Noises that appear to come from the transmission but actually originate at some other point are many and varied. For example, unbalanced propeller shaft, defective wheel bearings, or damaged tires on a vehicle may cause noises which are transmitted to the transmission. These noises have no particular or characteristic sounds that would indicate their origin; they are therefore difficult to identify.

Torsional vibration is one of the most frequent causes of noises that appear to be in the transmission, but actually originate outside of it. Included among these possible outside torsional vibrations are:

1. Propeller shaft (drive shaft) out of balance
2. Worn universal joints
3. Drive shaft center bearings loose
4. Worn and pitted teeth on axle pinion and ring gear
5. Wheels out of balance
6. Worn spring pivot bearings
7. Loose frame or axle U-bolts
8. Engine cooling fan out of balance
9. Engine crankshaft, flywheel, and/or clutch plate out of balance
10. Tires or wheels wobbly or mismatched.

This list, along with other troubles that you have encountered in your own experience, can be used as a step-by-step guide in transmission noise troubleshooting. Make sure that all possibility of outside noise has been eliminated before you remove the transmission.

When analyzing a vehicle for transmission noise, raise the vehicle so that the driving wheels are clear of the deck. Start and operate the vehicle in all the speed ranges, including COASTING with the shift lever in neutral. Listen carefully for noises and try to determine the origin. There are other procedures for checking transmission noises that may be used. Any procedure that is used relies principally on the experience and good judgment of the supervisor doing the troubleshooting.

When it is determined that the noise is within the transmission, generally it is necessary to remove the transmission from the vehicle and disassemble it.

Hard Shifting Into Gear

Hard shifting into gear can be caused by improper linkage adjustment between the gearshift lever and the transmission. The same trouble could result when the linkage is badly in need of lubrication, rusted, or jammed at any of the pivot points.

Other causes of hard shifting are failure of the clutch to release fully, the clutch linkage out of adjustment, or a warped friction disk or pressure plate that prevents full clutch disengagement. Gear clashing will continue, since the engine will still be delivering at least some power through the clutch to the transmission.

Inside the transmission, hard gear shifting could be due to a bent shifter fork, a sliding gear tight on the shaft splines, a battered sliding gear tooth, or a damaged synchronizing unit. If a bent shifter fork is making it necessary to exert greater pressure when shifting gears, it either should be replaced or, if not too badly bent, straightened and reused. If the splines in the gears or on the shaft become gummed up or battered from excessive wear so that the gear will not move easily along the shaft spline, then the shaft and gears should be cleaned or, if worn, replaced. When the sliding gear teeth have been battered, nothing can be done to repair the gears; new gears are required. The synchronizing unit could be tight on the shaft, or it could have loose parts, or worn or scored cones; any of these would increase the difficulty of gear meshing. To correct these and other troubles, the transmission must be removed, disassembled, parts replaced, reassembled, and remounted.

Slips Out of Gear

When the transmission slips out of gear, improper adjustment of the gearshift linkage between the gearshift lever and the transmission

can produce pressure on the linkage in such a way that the gears would work out of mesh.

Worn gears or gear teeth may also increase the chances of gears coming out of mesh. Likewise, if the detent balls (or lock-out mechanism in the transmission) lack sufficient spring pressure, there will be little to hold the gears in mesh, and they can slip out. Worn bearings or gears loose on the shaft tend to cause excessive end play or free motion which allows the gears to de-mesh.

When the transmission slips out of high gear, it could be due to misalignment between the transmission and the engine. If this condition exists and is allowed to continue, it could soon damage not only the clutch but transmission parts as well. This misalignment can often be detected by the action of the clutch pedal; it causes clutch-pedal pulsations, or nervous pedal. Check for misalignment by rotating the crankshaft slowly, and measuring the amount of wobble in the flywheel with a dial indicator. This amount should not exceed 0.005 inch. Remember to check the manufacturer's specifications which vary with different type vehicles.

No Power to the Propeller Shaft

If the transmission is in mesh, with the clutch engaged, and yet no power passes through the transmission to the propeller shaft, then it could be that the clutch is slipping. If the clutch is not slipping, trouble could then be in the transmission itself. Conditions inside the transmission that would prevent power from passing through to the propeller shaft include gear teeth being stripped, a shifter fork or some other linkage part broken, a gear or shaft broken, and a driving key or spline sheared off. To find and correct these possible troubles, remove the transmission, disassemble, replace those parts that are damaged or broken, reassemble, and remount.

Gears Clash When Shifting

Gear clashing that accompanies shifting into either second or high gear may be due to failure of the synchronizing mechanism to operate properly. This might well be caused by a broken synchronizer spring, incorrect synchronizer end play, or defective synchronizer cone surfaces. It could also be due to gears sticking on the main shaft or failure of the clutch to release fully. Gear clashing can also be obtained in low or reverse on many vehicles if a sudden shift is made to either of these positions while the gears are still in motion. In some transmissions these two gear positions do not have synchromesh devices. In these cases, to prevent gear clash when shifting into either of these positions, it is necessary to pause long enough to allow the gears to come to rest. Of course, if the clutch is not releasing fully, then the gears will still be driven and may clash when the shift is being made. Conditions that may prevent the clutch from releasing fully have been discussed and the procedures to follow for correcting these conditions have been discussed in preceding sections covering clutch troubleshooting.

Transmission Oil Leaks

Oil leaks that are observed in the transmission could result from any of the conditions noted below.

Lubricant in the transmission case which is not the correct type recommended by the manufacturer may foam excessively. As it foams, it will completely fill the case and begin to leak out. The same thing might happen if the oil level is too high. In addition, if the gaskets are broken or missing, or if seals and slingers are damaged or missing, oil will have a tendency to work past the shafts at both ends of the transmission.

Then too, if the drain plug is loose or if the transmission bearing retainer is not tightly bolted to the case, or if the case is cracked, oil will be lost. The right amount of the recommended oil should be used in the transmission to prevent excessive oil leakage due to foaming. Remove and disassemble the transmission so that the defective gaskets, oil seals, and slingers can be replaced. Reassemble the transmission after making these repairs and remount on the vehicle.

Transmission Noises

Several types of noise may be encountered in transmissions. Whining or growling, either steady or intermittent, may be due to worn, chipped, rough, or cracked gears. As the gears continue to wear, the noise may take on a grinding characteristic, particularly in the gear position that throws the greatest load on the worn gears. Bearing trouble often produces a hissing noise that will develop into a bumping or thudding sound as the bearings wear badly. Metallic rattles could be due to worn or loose shifting parts in the linkage or to gears loose on shaft splines. If the clutch friction-disk

cushion springs or the engine torsional-vibration dampener are defective, the torsional vibration of the engine will sometimes carry back into the transmission. This vibration would be apparent only at certain engine speeds.

When analyzing noise in the transmission, note whether the noise is obtained in neutral with the vehicle not moving or in certain gear positions. If the noise is evident with the transmission in neutral with the vehicle not moving, disengage the clutch. If this does not stop the noise, then the chances are the trouble is not in the transmission at all (provided the clutch actually disengages and does not have troubles such as stated in the preceding sections covering clutch troubleshooting). In this case, the noise is probably in the engine or the clutch. But if the noise stops when the clutch is disengaged, then the trouble is probably in the transmission.

Noise obtained in neutral with the clutch engaged could come from transmission misalignment with the engine, worn or dry bearings, worn gears, a worn or bent countershaft, or excessive end play of the countershaft. These are the parts that are in motion when the clutch is engaged and the transmission is in neutral.

Noise obtained in gear could also result from any of the conditions described in the previous paragraph. Also, it could be due to a defective friction disk in the clutch or a defective engine torsional-vibration dampener. In addition, the rear main bearing of the transmission could be worn or dry, gears could be loose on the main shaft, or gear teeth could be worn. Another cause of noise could be worn speedometer gears. By placing the transmission in the different gear positions and listening for the noise that is emitted, you will find it helpful in pinpointing the worn parts producing the noise.

As outlined in previous sections of this chapter, worn transmission parts should be replaced after transmission removal and disassembly.

TRANSFER CASES

Transfer cases are placed in the power trains of vehicles driven by all wheels. Their purpose is to provide the necessary offsets for additional propeller-shaft connections to drive the wheels.

Transfer cases in heavier vehicles have two speed positions and a declutching device for disconnecting the front driving wheels. Two speed transfer cases like the one shown in figure 9-12 serve also as auxiliary transmissions.

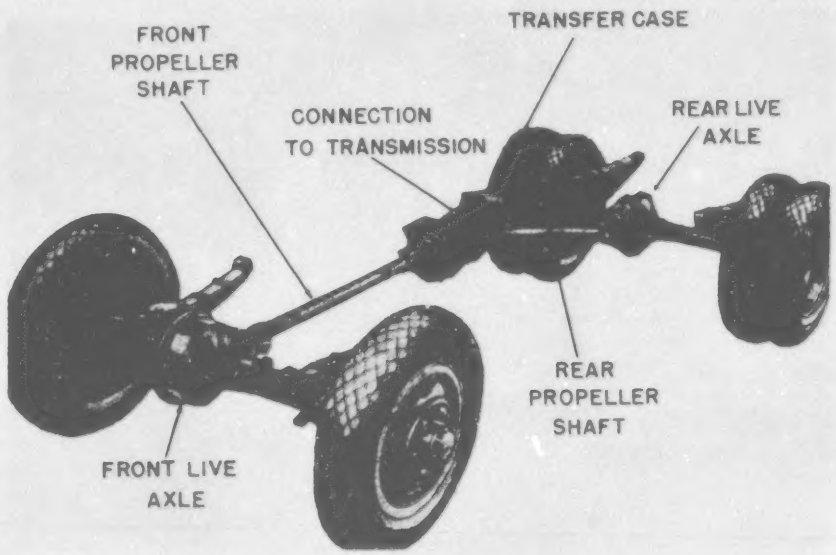

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Figure 9-12.—Transfer case installed in a 4-wheel drive truck.

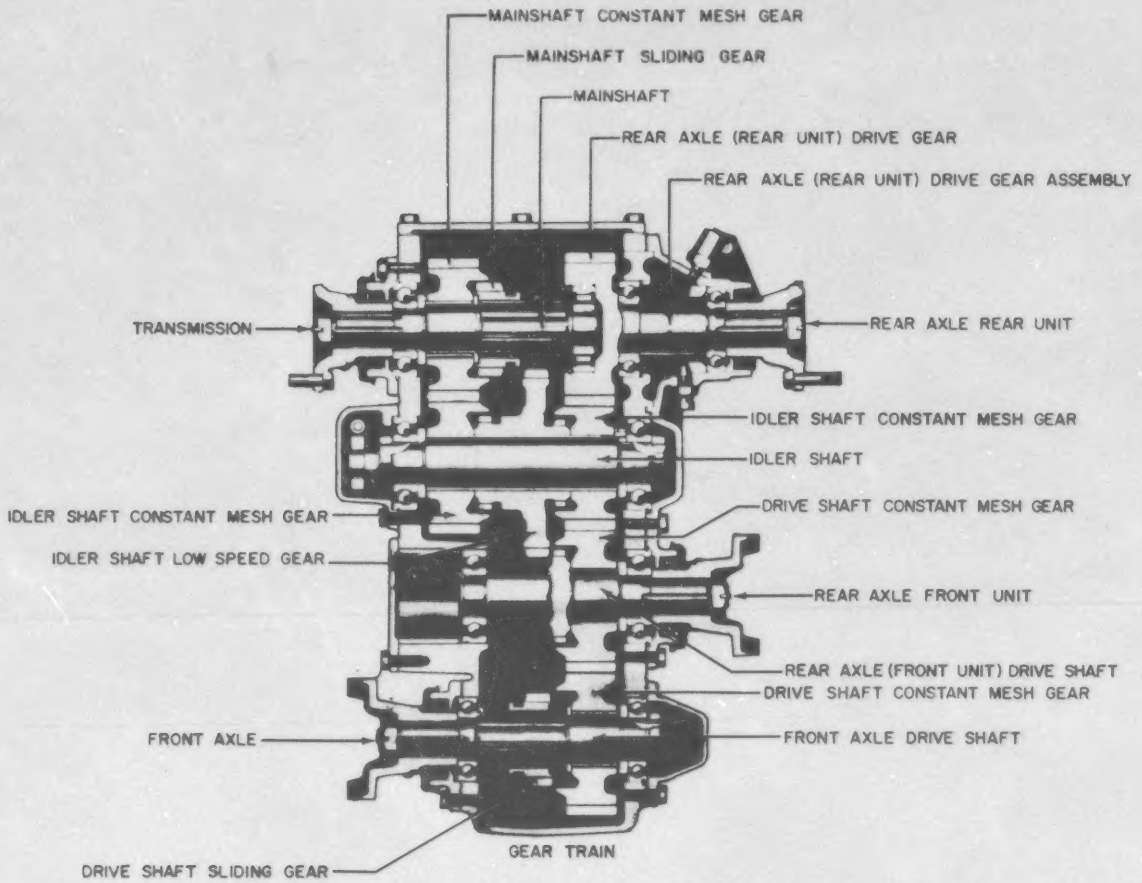

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Figure 9-13.—Cross-section of a 2-speed transfer case.

Some transfer cases are quite complicated. When they have speed changing gears, declutching devices, and attachments for three or more propeller shafts, they are even larger than the main transmission. A cross section of a common type of two-speed transfer case is shown in figure 9-13. Compare it with the actual installation in figure 9-12.

The declutching mechanism for the front wheels consists of a sliding sleeve spline clutch.

This same type of transfer case is used for a 6-wheel drive vehicle. The additional propeller shaft connects the drive shaft of the transfer case to the rearmost axle assembly. It is connected to the transfer case through the transmission brake drum.

Some transfer cases contain an overrunning sprag unit (or units) on the front output shaft. (A sprag unit is a form of overrunning clutch; power can be transmitted through it in one direction but not in the other.)

On these units the transfer is designed to drive the front axle slightly slower than the rear axle. During normal operation, when both front and rear wheels turn at the same speed, only the rear wheels drive the vehicle. However, if the rear wheels should lose traction and begin to slip, they tend to turn faster than the

front wheels. As this happens, the sprag unit automatically engages so that the front wheels also drive the vehicle. The sprag unit simply provides an automatic means of engaging the front wheels in drive whenever additional tractive effort is required. There are two types of sprag-unit-equipped transfers, a single-sprag-unit transfer and a double-sprag-unit transfer. Essentially, both types work in the same manner.

The first indication of trouble within a transfer case, as with other components of the power train, is usually "noisy" operation. If an operator reports trouble, make a visual inspection before removing the unit from the vehicle. Check for such things as oil level, oil leakage, and water in the oil.

Make sure the shift lever linkages are inspected. If the shift lever linkages are bent or improperly lubricated, it will be hard to shift the transfer case or in some cases will make shifting impossible. Make sure other possible troubles such as clutch slippage, damaged propeller shaft, and damaged axles have been eliminated.

Worn or broken gears, worn bearings, and excessive end play in the shafts will cause noisy operation of the transfer case. When it is decided that the trouble is within the transfer case, remove the unit from the vehicle for repairs.

Make sure the transfer case is thoroughly cleaned before disassembly of the unit begins. When the unit is disassembled, clean each part with an approved cleaning solvent. Inspection of the individual parts should follow the same procedure as outlined for transmissions. Avoid waste by reusing old parts that are in good condition.

If you are not thoroughly familiar with a particular make and model of transfer case, you should check the manufacturer's repair manual to ensure that proper adjustments and assembly procedures are followed.

POWER TAKEOFFS

Power takeoffs are attachments in the power train for power to drive auxiliary accessories. They are attached to the transmission, auxiliary transmission, or transfer case. A common type of power takeoff is the single-gear, single-speed type shown in figure 9-14. This unit is bolted to an opening provided in the side of the transmission case as shown in figure 10-10. The sliding gear of the power takeoff will then mesh with the transmission countershaft gear. The operator can move a shifter shaft control lever to slide the gear in and out of mesh with the counter shaft gear. The spring loaded ball holds the shifter shaft in position.

On some vehicles, you will find power takeoff units with gear arrangements that will give two speeds forward and one in reverse. Several forward speeds and a reverse gear arrangements are usually provided in power takeoff units which operate winches and hoists. Their operation is about the same as the single speed units.

The troubleshooting and repair procedures for the power takeoff are similar to those for the transfer case.

PROPELLER SHAFT ASSEMBLIES

The propeller shaft assembly consists of a propeller shaft, a slip joint, and one or more universal joints. This assembly provides a flexible connection through which power is transmitted from the transmission to the live axles.

The propeller shaft may be solid or tubular. A solid shaft is somewhat stronger than a hollow or tubular shaft of the same diameter, but a hollow shaft is stronger than a solid shaft of the same weight. Solid shafts are generally used inside of a shaft housing that encloses the entire propeller shaft assembly. These are called torque tube drives. To make repairs and adjustments to the propeller shaft assembly in a torque tube, you will have to remove the tube. Hollow shafts are used in the open. (See fig. 9-15.)

A slip joint is provided at one end of the propeller shaft to take care of end play. The driving axle, being attached to the springs, is free to move up and down while the transmission is attached to the frame and cannot move. Any upward or downward movement of the axle, as the springs are flexed, shortens or lengthens the distance between the axle assembly and the transmission. To compensate for this changing distance, the slip joint is provided at one end of the propeller shaft.

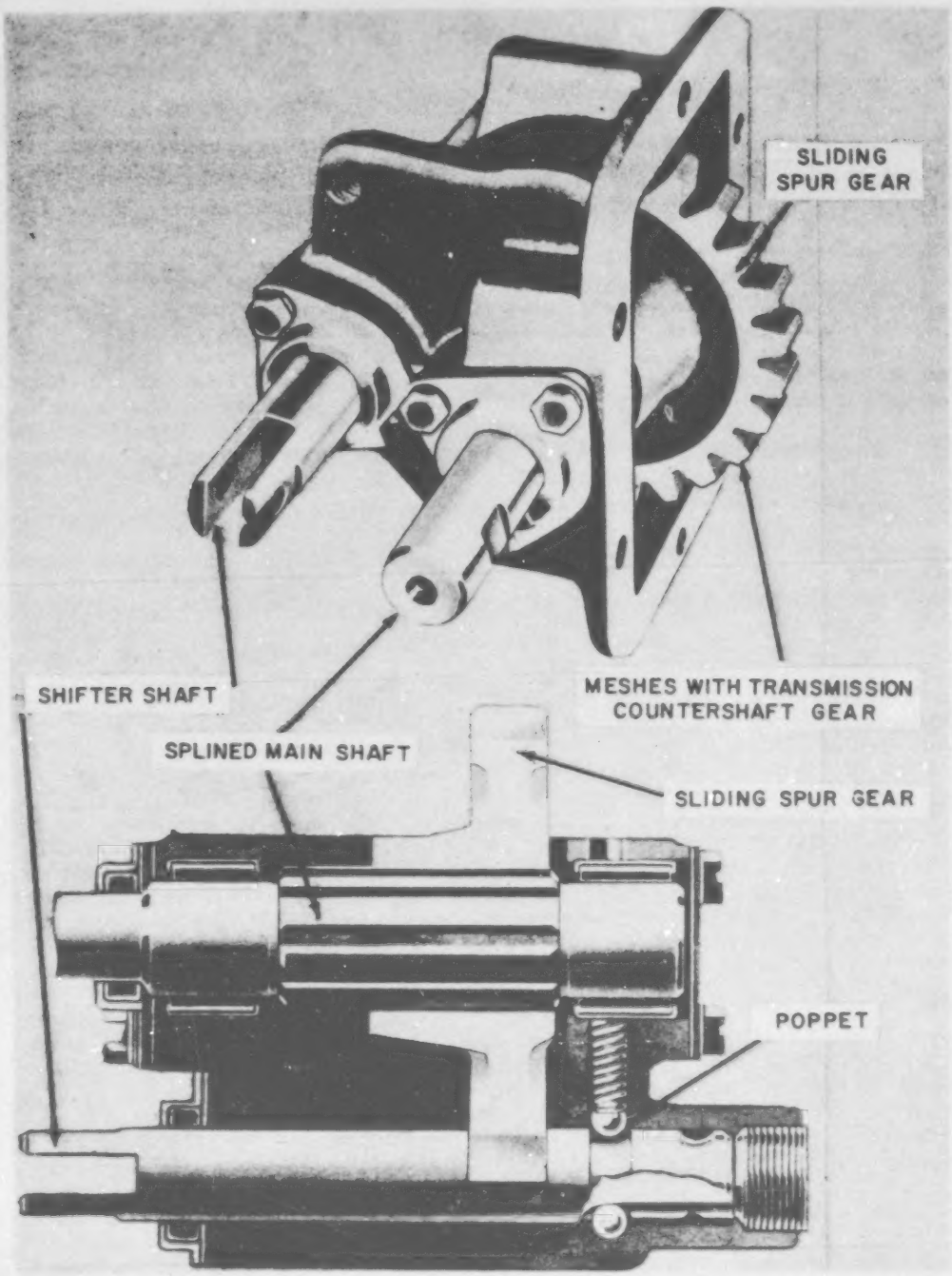

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Figure 9-14.—Single speed, single gear, power takeoff.

The usual type of slip joint consists of a splined stub shaft welded to the propeller shaft, which fits into a splined sleeve in the universal joint. A cross-sectional view of the slip joint and universal joint is shown in figure 9-16.

A universal joint is a connection between two shafts that permits one to drive the other at an angle. Passenger vehicles and trucks usually have universal joints at both ends of the propeller shaft.

Universal joints are double-hinged with the pins of the hinges set at right angles. They are made in many different designs, but they all work on the same principle. The universal joint shown in figure 9-17 is used in a torque tube drive, and the entire assembly is lubricated with a light grease within the bell housing which connects the torque tube to the rear end of the transmission case.

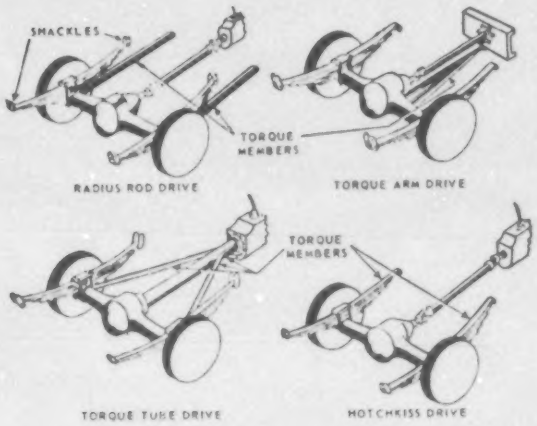

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Figure 9-15.—Types of drive.

Universal joints normally do not require any maintenance other than lubrication. Some universal joints (u-joints) have grease fittings and should be lubricated when the vehicle has a preventive maintenance inspection. Others may require disassembly and lubrication periodically. When lubricating "U" joints that have grease fittings, use a low pressure grease gun to avoid damaging seals.

DIFFERENTIALS

The purpose of the differential is easy to understand when you compare a vehicle to a company of men marching in mass formation. When the company makes a turn, the men in the inside file must take short steps, almost marking time, while men in the outside file must take long steps and walk a greater distance to make the turn. When a motor vehicle turns a corner, the wheels on the outside of the turn must rotate faster and travel a greater distance than the wheels on the inside. This causes no difficulty for front wheels of the usual passenger car because each wheel rotates independently. However, in order to drive the rear wheels

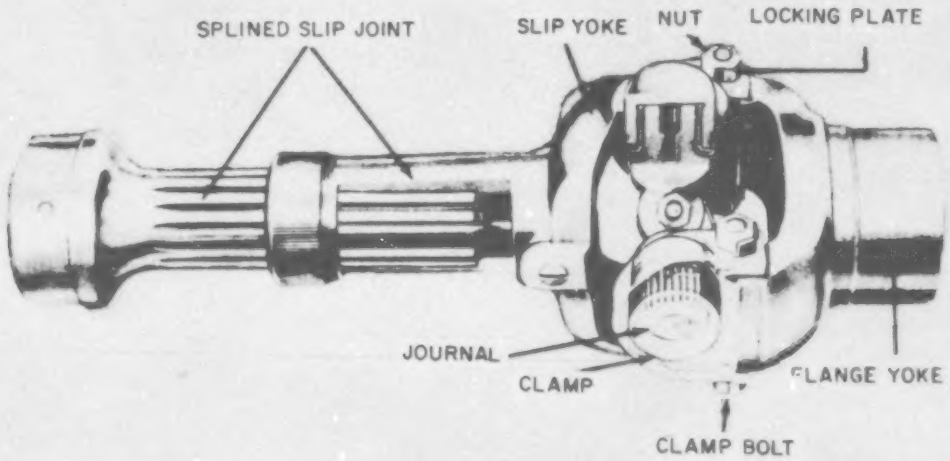

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Figure 9-16.—Slip joint and common type of universal joints.

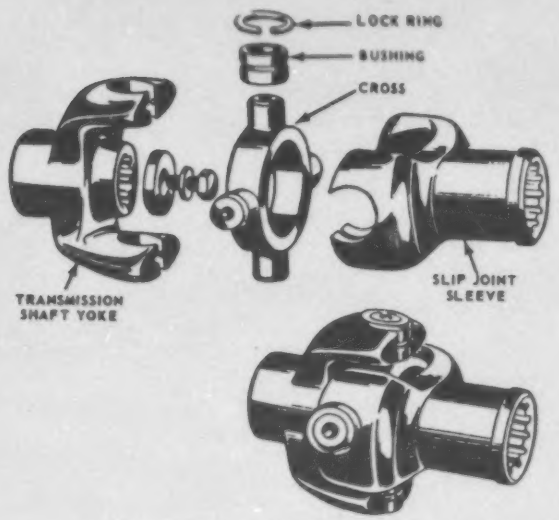

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Figure 9-17.—Ring and trunnion universal joint.

at different speeds, the differential is needed. It connects the individual axle shaft for each wheel to the bevel drive gear. Therefore, each shaft can turn at a different speed and still be driven as a single unit. Refer to the illustration in figure 9-18 as you study the following discussion on differential operation.

The bevel drive pinion, connected to the propeller shaft, rotates the bevel drive gear and the differential case which is attached to it. Within the case, the differential pinions are free to turn on individual pivots called trunnions. Power is transmitted to the axle shafts through the differential pinions and the side gears. The axle shafts are splined to the side gears and keyed or bolted to the wheels.

When the resistance is equal on each rear wheel, the differential pinions, side gears, and axle shafts all rotate as ONE UNIT with the drive gear. In this case, there is no relative motion between the pinions and the side gears in the differential case. That is, the pinions do not turn on the trunnions, and their teeth will not move over the teeth of the side gears.

When the vehicle turns a corner, one wheel must turn faster than the other. The side gear driving the outside wheel will run faster than the side gear connected to the axle shaft of the inside wheel. To compensate for this difference in speed, and to remain in mesh with the two side gears, the differential pinions must then turn on the trunnions. The average speed of the two side gears, axle shafts, or wheels is always equal to the speed of the bevel drive gear.

To overcome the situation where one spinning wheel might be undesirable, some trucks are provided with a DIFFERENTIAL LOCK. This is a simple dog clutch, controlled manually or automatically which locks one axle shaft to the differential case and bevel drive gear. Although this device forms a rigid connection between the two axle shafts and makes both wheels rotate at the same speed, it is used very little. Too often the driver forgets to disengage the lock after using it. There are, however, automatic devices for doing almost the same thing. One of these, which is rather extensively used today,

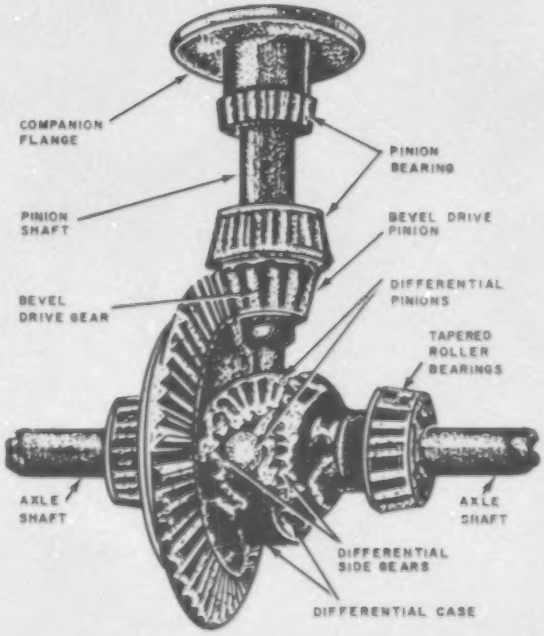

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Figure 9-18.—Differential with part of case cut away.

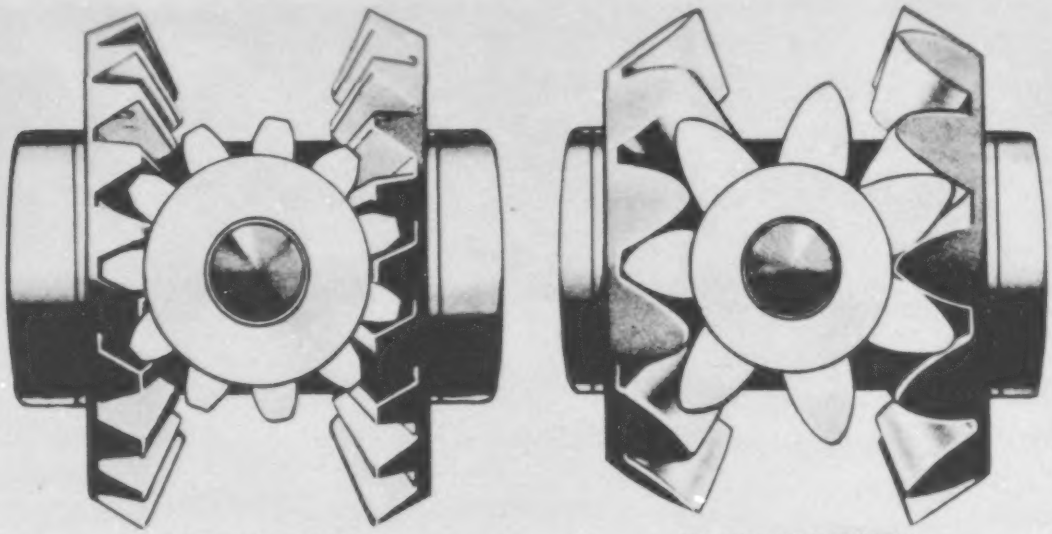

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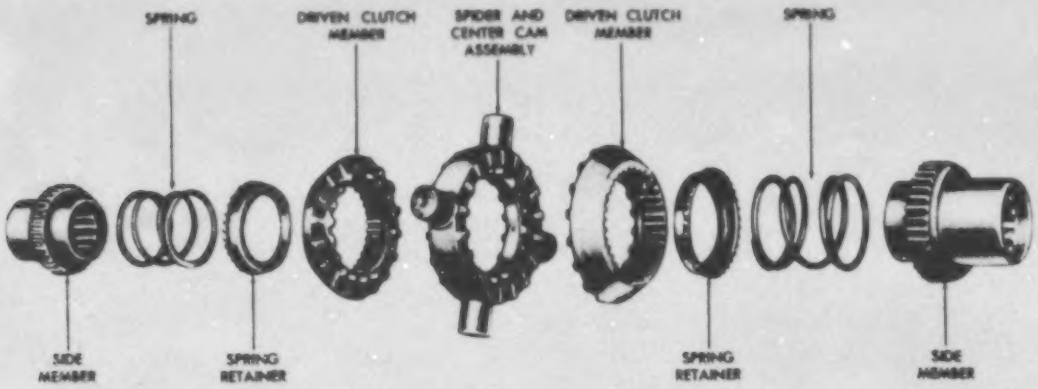
Figure 9-19.—Comparison of high-traction differential gears and standard differential gears.

is the high-traction differential. It consists of a set of differential pinions and side gears which have fewer teeth and a different tooth form from the conventional gears. Figure 9-19 shows a comparison between these and standard gears. These differential pinions and side gears depend on a variable radius from the center of the differential pinion to the point where it comes in contact with the side gear teeth, which is, in effect, a variable lever arm. As long as there is relative motion between the pinions and side gears, the torque is unevenly divided between the two driving shafts and wheels; whereas, with the usual differential, the torque is evenly divided at all times. With the high-traction differential, the torque becomes greater on one wheel and less on the other as the pinions move around until both wheels start to rotate at the same speed. When this occurs, the relative motion between the pinion and side gears stops and the torque on each wheel is again equal. This device assists considerably in starting the vehicle or keeping it rolling in cases where one wheel encounters a slippery spot and loses traction while the other wheel is on a firm spot and has traction. It will not work, however, when one wheel loses traction completely. In this respect it is inferior to the differential lock.

With the no-spin differential (fig. 9-20), one wheel cannot spin because of loss of tractive effort and thereby deprive the other wheel of driving effort. For example, one wheel is on ice and the other wheel is on dry pavement. The wheel on ice is assumed to have no traction. However, the wheel on dry pavement will pull to the limit of its tractional resistance at the pavement. The wheel on ice cannot spin because wheel speed is governed by the speed of the wheel applying tractive effort.

The no-spin differential does not contain pinion gears and side gears as does the conventional differential. Instead, it consists essentially of a spider attached to the differential drive ring gear through four trunnions, plus two driven clutch members with side teeth that are indexed by spring pressure with side teeth in the spider. Two side members are splined to the wheel axles and in turn are splined into the driven clutch members.



81.198

Figure 9-20.—No spin differential—exploded view.

DIFFERENTIAL TROUBLESHOOTING

The first hint of existing trouble in a differential is generally an unusual noise in the rear axle housing. To properly diagnose the trouble, however, you must determine the source of the noise and under what operating conditions the noise is most pronounced. Defective universal joints, rough rear wheel bearings, or tire noises may be improperly diagnosed by the inexperienced mechanic, as differential trouble. Some clue may be gained as to the cause of trouble by noting whether the noise is a growl, hum, or knock; whether it is heard when the car is operating on a straight road, or on turns only; and whether the noise is most noticeable when the engine is driving the vehicle or when it is coasting with the vehicle driving the engine.

A humming noise in the differential generally means the ring gear or pinion needs an adjustment. An improperly adjusted ring gear or pinion prevents normal tooth contact between the gears and therefore produces rapid gear tooth wear. If the trouble is not corrected immediately, the humming noise will gradually take on growling characteristics, and the ring gear and pinion will probably have to be replaced.

It is very easy to mistake tire noise for differential noise. Tire noise will vary according to the type of pavement the vehicle is being driven on, while differential noise will not. To confirm a doubt as to whether the noise is caused by tire or differential, drive the vehicle over various types of pavement.

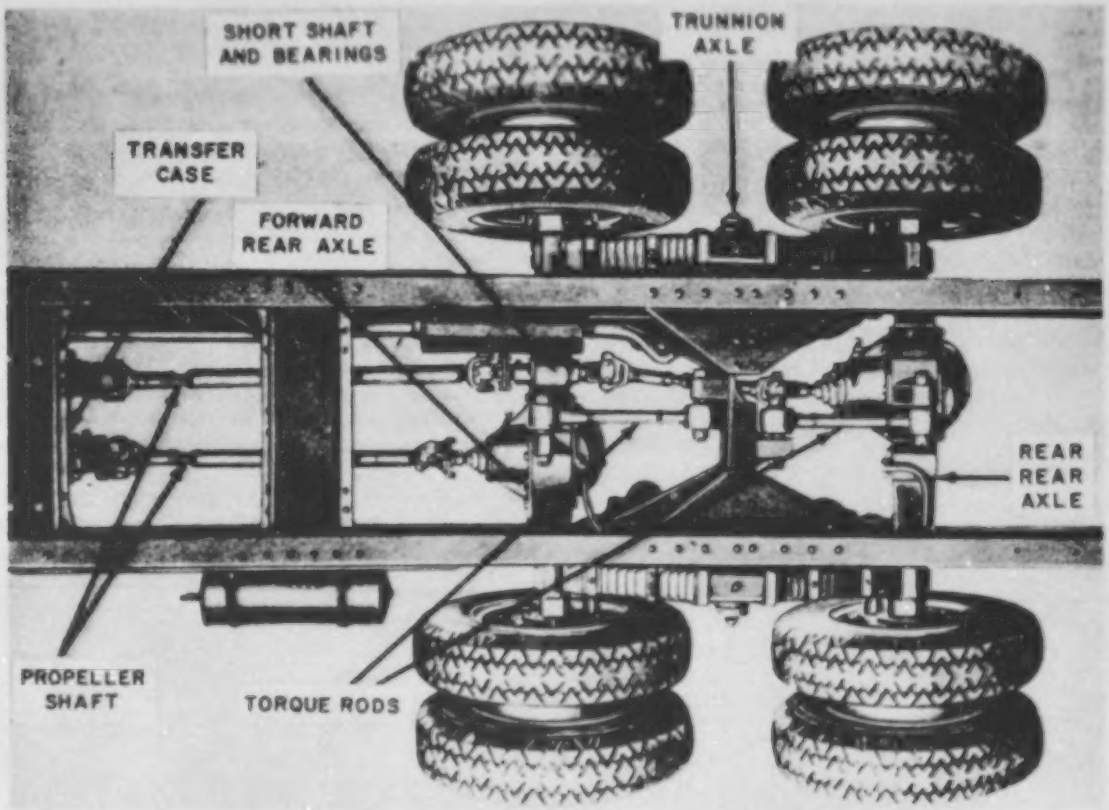
If a noise is present in the differential only when the vehicle is rounding a corner, the trouble is likely to be in the differential case assembly.

AXLES, WHEELS, AND TRACKS

A live axle is one that may support part of the weight of a vehicle and also drives the wheels connected to it. A dead axle is one that carries part of the weight of a vehicle but does not drive the wheels. The wheels rotate on the ends of the dead axle.

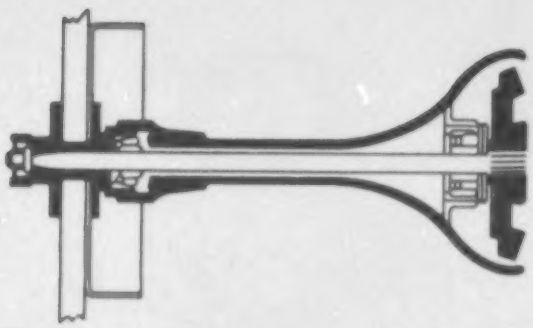
Usually, the front axle of a passenger car is a dead axle and the rear axle is a live axle. In 4-wheel drive vehicles, both front and rear axles are live axles, and in 6-wheel drive vehicles, all three axles are live axles. The third axle, part of a BOGIE DRIVE, is joined to the rearmost axle by a trunnion axle as shown in figure 9-21. The axle trunnion is attached rigidly to the frame. Its purpose is to help in distributing the load on the rear of the vehicle to the two live axles which it connects.

There are FOUR types of live axles used in automotive and construction equipment. They are: plain, semifloating, three-quarter floating, and full floating.



81.199

Figure 9-21.—Bogie 4-wheel drive with independent propeller shafts.



81.200

Figure 9-22.—Semifloating rear axle.

The PLAIN LIVE AXLE, or nonfloating rear axle, is seldom used in construction equipment today. The axle shafts in this assembly are called nonfloating because they are supported directly in bearings located in the center and ends of the axle housing. In addition to turning the wheels, these shafts carry the entire load of the vehicle on their outer ends. Plain axles also support the weight of the differential case.

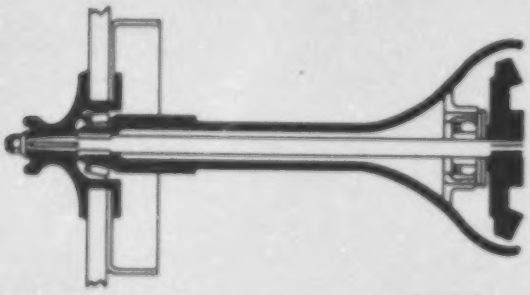
The SEMIFLOATING AXLE (fig. 9-22) that is used on most passenger cars and light trucks has its differential case independently supported. The differential carrier relieves the axle shafts from the weight of the differential assembly and the stresses caused by its operation. For this reason the inner ends of the axle shafts are said to be floated. The wheels are keyed or bolted to

outer ends of axle shafts and the outer bearings are between the shafts and the housing. The axle shafts therefore must take the stresses caused by turning or skidding of the wheels. The axle shaft in a semifloating live axle can be removed after the wheel and brake drum have been removed.

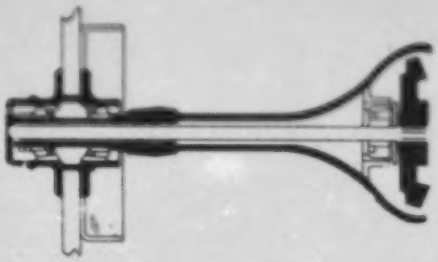
The axle shafts in a THREE-QUARTER FLOATING AXLE (fig. 9-23) may be removed with the wheels, which are keyed to the tapered outer ends of the shafts. The inner ends of the shafts are carried as in a semifloating axle. The axle housing, instead of the shafts, carries the weight of the vehicle because the wheels are supported by bearings on the outer ends of the housing. However, axle shafts must take the stresses caused by the turning, or skidding, of the wheels. Three-quarter floating axles are used in some trucks but in very few passenger cars.

The FULL FLOATING AXLE is used in most heavy trucks. (See fig. 9-24.) These axle shafts may be removed and replaced without removing the wheels or disturbing the differential. Each wheel is carried on the end of the axle tube on two ball bearings or roller bearings and the axle shafts are bolted to the wheel hub. The wheels are driven through a flange on the ends of the axle shaft which is bolted to the outside of the wheel hub. The bolted connection between axle and wheel does not make this assembly a true full floating axle, but nevertheless, it is called a floating axle. A true full floating axle transmits only turning effort, or torque.

Wheels attached to live axles are the DRIVING WHEELS. The number of wheels and number



81.201
Figure 9-23.—Three-quarter floating rear axle.



81.202
Figure 9-24.—Full floating rear axle.

of driving wheels is sometimes used to identify equipment. You, as a mechanic, may identify a truck by the gasoline or diesel engine that provides the power. Then again, you may refer to it as a bogie drive.

Wheels attached to the outside of the driving wheels make up DUAL WHEELS. Dual wheels give additional traction to the driving wheels and distribute the weight of the vehicle over a greater area of road surface. They are considered as single wheels in describing vehicles. For example, a 4 x 2 (four by two) could be a passenger car or a truck having 4 wheels with 2 of them driving. A 4 x 4 indicates a vehicle having 4 wheels with all 4 driving. In some cases, these vehicles will have dual wheels in the rear. You would describe such a vehicle as a 4 x 4 with dual wheels.

A 6 x 4 truck, although having dual wheels in the rear, is identified by 6 wheels, 4 of them driving. Actually, the truck has 10 wheels but the 4 wheels attached to the driving wheels could be removed without changing the identity of the truck. If the front wheels of this truck were driven by a live axle, it would be called a 6 x 6.

The tracks on tracklaying vehicles are driven in much the same manner as wheels on wheeled vehicles. Sprockets instead of wheels are driven by live axles to move the tracks on the rollers. These vehicles are identified as either full-track, half-track, or vehicles that can be converted.

FULL TRACK vehicles are entirely supported, driven, and steered by two tracks which replace all wheels.

HALF-TRACK vehicles are supported and steered by wheels at the front, and are driven and supported by tracks at the rear. In addition to having driving tracks, some half-track vehicles are also provided with front driven axles.

SERVICE AND MAINTENANCE

There are very few adjustments to be made in power trains during normal operation. Most of your duties concerned with power trains will be limited to preventive maintenance. You will be working with the disassembly, repair, and reassembly of transmissions, rear axles, and propeller shaft assemblies when they break down. You will also inspect these units for indications of major repairs needed. Major repairs can be reduced by proper lubrication and periodic inspection of gear cases, propeller shafts, and wheel bearings.

Proper lubrication depends upon the use of the right kind of lubricants which must be put in the right places in the amounts specified by the LUBRICATION CHARTS. The charts provided with the vehicle will also show what units in the power train will require lubrication, and where they are located. These units are similar to the ones described and illustrated in this chapter.

In checking the level of the lubricant in GEAR CASES and before you add oil, keep these two important points in mind:

First, always carefully wipe the dirt away from around the inspection plug and then use the proper size wrench to remove and tighten the inspection plugs. A wrench too large will round the corners and prevent proper tightening of the plug. For the same reason, never use a pipe wrench or a pair of pliers for removing plugs.

Secondly, be sure the level of the lubricant is right—usually just below or on a level with the bottom of the inspection hole. Before checking the level, allow the vehicle to stand for a while on a level surface so the oil can cool and find its own level. Oil heated and churned by revolving gears expands and forms bubbles. Although too little oil in the gear boxes is responsible for many failures of the power train, do not add too much gear lubricant. Too much oil results in extra maintenance.

Excessive oil or grease can find its way past the oil seals or gear cases. It may be forced out of a transmission into the clutch housing and result in a slipping clutch; or it may get by the rear wheel bearings from the differential housing to cause brakes to slip or grab. In either case, you will have extra work to do. Always clean differential and live axle housing vents to prevent pressure build-up (caused by heat) which can result in leaking seals.

UNIVERSAL JOINTS and SLIP JOINTS at the ends of propeller shafts are to be lubricated if fittings are provided. The same holds true for WHEEL BEARINGS. Some of these joints and bearings are packed with grease when assembled, others have grease fittings or small plugs, with screwdriver slots, that can be removed for inserting grease fittings. Do not remove these plugs until you consult the manual or your chief for instructions.

Some passenger cars and trucks have a leather boot or shoe covering the universal and slip joints. The boot prevents grease from being thrown from the joints and it also keeps dirt from mixing with the grease. A mixture of dirt and grease forms an abrasive that will wear parts in a hurry. Never use so much grease on these joints that the grease will be forced out of the boot. The extra grease will be lost and the added weight of the grease will tend to throw the propeller shaft out of balance.

When you are to give a vehicle a thorough inspection, inspect the power trains for loose gear housings and joints. Look for bent propeller shafts that are responsible for vibrations, and examine the gear housings and joints for missing screws and bolts. Check to see that the U-bolts fastening the springs to the rear axle housing are tight. A loose spring hanger can throw the rear axle assembly out of line, and place additional strain on the propeller shaft and final drive. When making these inspections, always tighten the lugs that fasten wheels to live axles.

After tightening gear housings, loose connections, and joints, if no major repairs are required, road test the vehicle to see if the various units in the power train are working properly. Shift the gears into all operating speeds and listen for noisy or grinding gears.

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QUALIFICATIONS FOR ADVANCEMENT

This is a list of the minimum qualifications for advancement to Construction Mechanic First and Chief. The official source of this list is the Manual of Qualifications for Advancement, NAVPERS 18068-C, change 7. The numbers given opposite the qualifications designate the assignments of your Nonresident Career Course in which the practical or knowledge factors are covered.

CONSTRUCTION MECHANIC 1 & C

Construction Mechanics perform tasks involved in maintenance, repair, and overhaul of automotive, materials-handling, and construction equipment; assign and supervise activities of assistants who locate, analyze, and correct malfunctions in equipment, and issue repair parts; maintain records, prepare requisitions and reports; train assistants in repair procedures and techniques.

QUALIFICATIONS FOR ADVANCEMENT	Required for Advancement to CM	Covered in Assignment
A. SAFETY		
Note: The safe use of tools, machines, equipment, parts, and materials related to the Construction Mechanic rating is considered an integral part of every practical factor; and as such, it must be observed and checked during the actual performance of the skill or task. This section contains qualifications applicable to safety precautions which are general in nature, or are related to enforcing safety regulations and supervising safety programs.		
1.00 Practical Factors		
.60 Inspect work areas, tools, and equipment to detect potentially hazardous and unsafe conditions and take corrective action	E-6	1, 2
.80 Administer a company accident prevention program . . .	E-7	1, 2
2.00 Knowledge Factors		
None.		

QUALIFICATIONS FOR ADVANCEMENT	Required for Advancement to CM	Covered in Assignment
C. INTERNAL COMBUSTION ENGINES		
1.00 Practical Factors		
.60 Perform major overhaul on internal combustion engines. .	E-6	4, 5
.61 Diagnose engine malfunctions and prescribe corrective action through major engine overhaul	E-6	4, 5
.62 Diagnose malfunctions of turbo-chargers and blowers and overhaul as required	E-6	4, 5, 6, 7
2.00 Knowledge Factors		
.60 Use and operating procedures of engine and chassis dynometers.	E-6	4, 5
D. FUEL SYSTEMS AND CARBURETION		
1.00 Practical Factors		
.60 Test, overhaul, and adjust diesel engine fuel injection pumps and nozzles	E-6	6, 7
.61 Diagnose diesel fuel system malfunctions and prescribe corrective action	E-6	6, 7
2.00 Knowledge Factors		
None.		
E. ELECTRICAL: STARTING AND GENERATING CIRCUITS		
1.00 Practical Factors		
.60 Troubleshoot starting and generating circuits and prescribe corrective action	E-6	5
.61 Test and adjust output controls of generating circuits	E-6	5
2.00 Knowledge Factors		
None.		
F. ELECTRICAL: BATTERIES, LIGHT AND ACCESSORY CIRCUITS		
1.00 Practical Factors		
.60 Perform amperage draw test on storage batteries . . .	E-6	5
2.00 Knowledge Factors		
None.		

QUALIFICATIONS FOR ADVANCEMENT	Required for Advancement to CM	Covered in Assignment
G. ELECTRICAL: IGNITION CIRCUIT		
1.00 Practical Factors		
.60 Use electrical test equipment to diagnose ignition system malfunctions and recommend corrective action . .	E-6	5
2.00 Knowledge Factors		
None.		
H. POWER TRAINS		
1.00 Practical Factors		
.60 Diagnose abnormal condition in power train unit (except torque converters and automatic and power-shift transmissions) and prescribe corrective action	E-6	7, 8
2.00 Knowledge Factors		
None.		
J. BRAKE SYSTEMS		
1.00 Practical Factors		
.60 Troubleshoot hydraulic, air, vacuum, and electric brake systems and recommend corrective action	E-6	7
2.00 Knowledge Factors		
None.		
Z. ADMINISTRATION		
1.00 Practical Factors		
.59 Plan day-to-day work assignments for the following:		
b. [illegible]am/crew leaders	E-6	1, 2
c. [illegible]ipment Maintenance/Repair Platoons	E-7	1, 2
.61 Supervise the preparation and maintenance of vehicle and equipment history jackets	E-6	2, 3
.62 Prepare vehicle and equipment inspection reports . . .	E-6	2, 3
.64 Supervise and inspect the work of personnel engaged in servicing and repairing automotive, materials/weight-handling, and construction equipment	E-6	7
.65 Conduct a PRCP interview	E-6	1, 2
.81 Supervise general job operations involving service and repair of automotive, materials/weight-handling, and construction equipment.	E-7	2, 3

QUALIFICATIONS FOR ADVANCEMENT	Required for Advancement to CM	Covered in Assignment
Z. ADMINISTRATION-Continued		
2.00 Knowledge Factors		
.62 Principles and techniques of supervision and job control.	E-6	1, 2
.64 Procedures for checking personnel out on Practical Factors.	E-6	1, 2
.80 Procedures for conducting the "Battalion Equipment Evaluation Program" (BEEP)	E-7	2, 3
.81 Duties and responsibilities of the following:		
a. Equipment Company Shops Supervisor/Coordinator . .	E-7	2, 3
b. Public Works Transportation Shops Supervision. . .	E-7	2

CONSTRUCTION MECHANIC 1 & C

NAVEDTRA 10645-E

Prepared by the Naval Education and Training Program Development Center, Pensacola, Florida

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Your NRCC contains a set of assignments and self-scoring answer sheets (packaged separately). The Rate Training Manual, Construction Mechanic 1 & C, NAVEDTRA 10645-E, is your textbook for the NRCC. If an errata sheet comes with the NRCC, make all indicated changes or corrections. Do not change or correct the textbook or assignments in any other way.

HOW TO COMPLETE THIS COURSE SUCCESSFULLY

Study the textbook pages given at the beginning of each assignment before trying to answer the items. Pay attention to tables and illustrations as they contain a lot of information. Making your own drawings can help you understand the subject matter. Also, read the learning objectives that precede the sets of items. The learning objectives and items are based on the subject matter or study material in the textbook. The objectives tell you what you should be able to do by studying assigned textual material and answering the items.

At this point you should be ready to answer the items in the assignment. Read each item carefully. Select the BEST ANSWER for each item, consulting your textbook when necessary. Be sure to select the BEST ANSWER from the subject matter in the textbook. You may discuss difficult points in the course with others. However, the answer you select must be your own. Use only the self-scoring answer sheet designated for your assignment. Follow the scoring directions given on the answer sheet itself and elsewhere in this course.

Your NRCC will be administered by your command or, in the case of small commands, by the Naval Education and Training Program Development Center. No matter who administers your course you can complete it successfully by earning grades that average 3.2 or higher. If you are on active duty, the average of your grades in all assignments must be at least 3.2. If you are NOT on active duty, the average of your grades in all assignments of each creditable unit must be at least 3.2. The unit breakdown of the course, if any, is shown later under Naval Reserve Retirement Credit.

WHEN YOUR COURSE IS ADMINISTERED BY LOCAL COMMAND

As soon as you have finished an assignment, submit the completed self-scoring answer sheet to the officer designated to administer it. He will check the accuracy of your score and discuss with you the items that you do not understand. You may wish to record your score on the assignment itself since the self-scoring answer sheet is not returned.

If you are completing this NRCC to become eligible to take the fleetwide advancement examination, follow a schedule that will enable you to complete all assignments in time. Your schedule should call for the completion of at least one assignment per month.

Although you complete the course successfully, the Naval Education and Training Program Development Center will not issue you a letter of satisfactory completion. Your command will make a note in your service record, giving you credit for your work.

WHEN YOUR COURSE IS ADMINISTERED BY THE NAVAL EDUCATION AND TRAINING PROGRAM DEVELOPMENT CENTER

After finishing an assignment, go on to the next. Retain each completed self-scoring answer sheet until you finish all the assignments in a unit (or in the course if it is not divided into units). Using the envelopes provided, mail your self-scored answer sheets to Naval Education and Training Program Development Center where the scores will be verified and recorded. Make sure all blanks at the top of each answer sheet are filled in. Unless you furnish all the information required, it will be impossible to give you credit for your work. You may wish to record your scores on the assignments since the self-scoring answer sheets are not returned.

The Naval Education and Training Program Development Center will issue a letter of satisfactory completion to certify successful completion of the course (or a creditable unit of the course). To receive a course-completion letter, follow the directions given on the course-completion form in the back of this NRCC.

You may keep the textbook and assignments for this course. Return them only in the event you disenroll from the course or otherwise fail to complete the course. Directions for returning the textbook and assignments are given on the book-return form in the back of this NRCC.

PREPARING FOR YOUR ADVANCEMENT EXAMINATION

Your examination for advancement is based on the Manual of Qualifications for Advancement (NAVPERS 18068). The sources of questions in this examination are given in the Bibliography for Advancement Study (NAVEDTRA 10052). Since your NRCC and textbook are among the sources listed in this bibliography, be sure to study both in preparing to take your advancement examination. The qualifications for your rating may have changed since your course and textbook were printed, so refer to the latest editions of NAVPERS 18068 and NAVEDTRA 10052.

NAVAL RESERVE RETIREMENT CREDIT

This course is evaluated at 12 Naval Reserve retirement points, which will be credited upon satisfactory completion of the entire course. These points are creditable to personnel eligible to receive them under current directives governing the retirement of Naval Reserve personnel.

Credit cannot be given again for this course if the student has previously received credit for completing another Construction Mechanic 1 & C NRCC or ECC.

COURSE OBJECTIVE

In completing this Nonresident Career Course, you will demonstrate a knowledge of the subject matter by correctly answering items on the following: major duties and responsibilities of the Construction Mechanic; principles of supervision; implementing a battalion safety program at company level; purpose of the Personnel Readiness Capability Program; organization of a Public Works Transportation Department; procedures for preserving, depreserving, and storing equipment; principles and techniques of preventive maintenance; field maintenance and repair of construction equipment; fundamentals of a Public Works cost control system; organization of the equipment maintenance branch in an NMCB; outfitting repair parts allowances for support of battalion equipment; procedures for conducting the Battalion Equipment Evaluation Program; overhauling internal combustion engines; troubleshooting vehicle electrical systems, fuel systems, brake systems, air induction systems, and power trains; and safety inspections of motor vehicles.

Naval nonresident career courses may include a variety of items -- multiple-choice, true-false, matching, etc. The items are not grouped by type; regardless of type, they are presented in the same general sequence as the textbook material upon which they are based. This presentation is designed to preserve continuity of thought, permitting step-by-step development of ideas. Some courses use many types of items, others only a few. The student can readily identify the type of each item (and the action required of him) through inspection of the samples given below.

MULTIPLE-CHOICE ITEMS

Each item contains several alternatives, one of which provides the best answer to the item. Select the best alternative and erase the appropriate box on the answer sheet.

SAMPLE

s-1. The first person to be appointed Secretary of Defense under the National Security Act of 1947 was
1. George Marshall
2. James Forrestal
3. Chester Nimitz
4. William Halsey

The erasure of a correct answer is indicated in this way on the answer sheet:

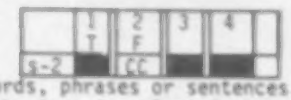
TRUE-FALSE ITEMS

Determine if the statement is true or false. If any part of the statement is false the statement is to be considered false. Erase the appropriate box on the answer sheet as indicated below.

SAMPLE

s-2. Any naval officer is authorized to correspond officially with a bureau of the Navy Department without his commanding officer's endorsement.

The erasure of a correct answer is also indicated in this way on the answer sheet:



MATCHING ITEMS

Each set of items consists of two columns, each listing words, phrases or sentences. The task is to select the item in column B which is the best match for the item in column A that is being considered. Specific instructions are given with each set of items. Select the numbers identifying the answers and erase the appropriate boxes on the answer sheet.

SAMPLE

In items s-3 through s-6, match the name of the shipboard officer in column A by selecting from column B the name of the department in which the officer functions.

A. Officers	B. Departments
s-3. Damage Control Assistant	1. Operations Department
s-4. CIC Officer	2. Engineering Department
s-5. Assistant for Disbursing	3. Supply Department
s-6. Communications Officer	

The erasure of a correct answer is indicated in this way on the answer sheet:

How To Score Your Immediate Knowledge of Results (IKOR) Answer Sheets

Total the number of incorrect erasures (those that show page numbers) for each item and place in the blank space at the end of each item.

Sample only

Number of boxes erased incorrectly	0-2	3-7	8-
Your score	4.0	3.9	3.8

Now TOTAL the column(s) of incorrect erasures and find your score in the Table at the bottom of EACH answer sheet.

NOTICE: If, on erasing, a page number appears, review text (starting on that page) and erase again until "C", "CC", or "CCC" appears. For courses administered by the Center, the maximum number of points (or incorrect erasures) will be deducted from each item which does NOT have a "C", "CC", or "CCC" uncovered (i.e., 3 pts. for four choice items, 2 pts. for three choice items, and 1 pt. for T/F items).

Assignment 1

Duties and Responsibilities, and Supervision

Textbook Assignment, NAVEDTRA 10645-E: Pages 1 - 15

In this course you will demonstrate that learning has taken place by correctly answering training items. The mere physical act of indicating a choice on an answer sheet is not in itself important; it is the mental achievement, in whatever form it may take, prior to the physical act that is important and toward which nonresident career course learning objectives are directed. The selection of the correct choice for a course training item indicates that you have fulfilled, at least in part, the stated objective(s).

The accomplishment of certain objectives, for example, a physical act such as drafting a memo, cannot readily be determined by means of objective type course items; however, you can demonstrate by means of answers to training items that you have acquired the requisite knowledge to perform the physical act. The accomplishment of certain other learning objectives, for example, the mental acts of comparing, recognizing, evaluating, choosing, selecting, etc., may be readily demonstrated in a course by indicating the correct answers to training items.

The comprehensive objective for this course has already been given. It states the purpose of the course in terms of what you will be able to do as you complete the course.

The detailed objectives in each assignment state what you should accomplish as you progress through the course. They may appear singly or in clusters of closely related objectives, as appropriate; they are followed by items which will enable you to indicate your accomplishment.

All objectives in this course are learning objectives and items are teaching items. They point out important things, they assist in learning, and they should enable you to do a better job for the Navy.

This self-study course is only one part of the total Navy training program; by its very nature it can take you only part of the way to a training goal. Practical experience, schools, selected reading, and the desire to accomplish are also necessary to round out a fully meaningful training program.

Learning Objective: Point out some of the major duties and responsibilities of the Construction Mechanic and requirements for advancement. Textbook pages 1 through 4.

1-1. One of the most enduring rewards of advancement is the personal satisfaction to be gained from the
1. higher standard of living you can maintain because of increased pay
2. skills you develop and knowledge you acquire
3. greater prestige you acquire when given more authority
4. formal education you receive while preparing for advancement

1-2. As a Construction Mechanic advances, he increases his value to the Navy by being a supervisor, leader, and instructor.

1-3. As a Construction Mechanic advances to CM1 or CMC, he should increase his knowledge about the work of other Group VIII ratings, military leadership, and the mission of the command.

1-4. As a CM1 or CMC, your increasing responsibilities for military and technical leadership will NOT require you to
1. see that your subordinates perform their work properly
2. be a training specialist
3. understand the duties and responsibilities of others
4. be a subject matter specialist for all Group VIII ratings

1-5. You can keep abreast of new developments that affect you, your work, and the Navy by being able to
1. find up-to-date information and check that which pertains to your rating
2. collect personal copies of pertinent technical manuals
3. complete all nonresident career courses that pertain to your rating
4. complete all officer correspondence courses that relate to your work

1-6. All the following are Construction Mechanic's duties EXCEPT
1. maintaining records, preparing requisitions, and reports
2. training assistants in repair procedures and techniques
3. performing operator's maintenance of automotive, materials-handling, and construction equipment
4. assigning and supervising the work of assistants who locate, analyze, and correct malfunctions in equipment

1-7. In a battalion, a CM1 or CMC may be assigned to
1. supervise a transportation division
2. administer the safety program
3. supervise a transportation equipment maintenance shop
4. instruct subordinates in career planning

1-8. All of the following are requirements for advancement to CM1 or CMC EXCEPT
1. completing the required military and professional training manuals
2. being recommended by your educational services officer
3. passing a servicewide competitive examination
4. being able to perform all factors listed on NAVEDTRA 1414/1 CM

Learning Objective: Identify uses and meanings of technical terms. Textbook pages 2 and 3.

1-9. As a supervisor, you should be precise in the use of technical and standard Navy terms in order to
1. avoid criticism by trainees having a higher formal education
2. impress the trainee with your superior command of language
3. convey information accurately, simply, and clearly
4. take advantage of the opportunity for self-improvement

In items 1-10 through 1-13, select from column B the definition for the term in column A.

A. Terms	B. Definitions
1-10. Minor repair	1. Use or operate instruments to identify possible malfunction or failure
1-11. Test	2. Use precision measuring devices to measure clearances
1-12. Minor engine tune-up	3. Replace worn or broken parts and restore equipment (or facilities) to its original capability by adjustments not requiring a high degree of technical skill
1-13. Adjust	4. Clean or renew spark plugs, renew ignition points and condenser, set ignition timing and idle speed; service carburetor and air cleaners; clean and renew fuel bowl filter or screen

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Learning Objective: Indicate the purpose or use of BUPERS and NAVEDTRA publications, NAVFAC publications, manufacturers' manuals, and training films which should help you in preparing for advancement. Textbook pages 4 through 7.

1-14. In preparing for advancement, you should familiarize yourself with Manual of Qualifications for Advancement, the Record of Practical Factors, appropriate Rate Training Manuals, and other material that is required or recommended in the
1. Basic Military Requirements training manual
2. Bibliography for Advancement Study
3. List of Training Manuals and Correspondence Courses

1-15. One of the purposes of the CM1 and CMC Rate Training Manual is to provide information on the
1. military requirements for advancement to CM1 and CMC
2. occupational qualifications for advancement to CM1 and CMC
3. practical factors of occupational qualifications for advancement to CM1 and CMC
4. military requirements and occupational qualifications for advancement to CM1 and CMC

1-16. What part of a Rate Training Manual will give you an overview of its organization before you start to study it?
1. Preface
2. Table of contents
3. Appendix
4. Index

1-17. Your Rate Training Manual is designated by NAVEDTRA 10645-E. Which part of the designation identifies the subject matter?
1. The set of numbers only
2. The letter E only
3. The set of numbers and the letter E

1-18. Which qualifications or requirements are covered by the Quals Manual?
1. Occupational requirements of all ratings
2. Professional requirements for personnel advancement only
3. Qualifications for general ratings but not for service ratings
4. Military requirements for all ratings and occupational requirements specific to each rating

1-19. Which of the following statements concerning the quals or the Quals Manual is false?
1. The Quals Manual is kept current by means of numbered changes
2. The Quals Manual lists the minimum requirements for advancement to each rate within each rating
3. Each qual has a designated paygrade
4. You are responsible only for the quals specifically listed for the paygrade to which you seek advancement

1-20. The questions contained in a written examination for advancement to CM1 or CMC are related to
1. practical factors of occupational qualifications only
2. practical factors of military/leadership requirements only
3. knowledge factors of military/leadership requirements only
4. all the above practical and knowledge factors

1-21. The Record of Practical Factors is NOT used for recording an individual's satisfactory completion of
1. practical factors of his military qualifications for advancement
2. practical factors of his occupational qualifications for advancement
3. skills that are within the general scope of his rating but not identified as minimum qualifications for advancement
4. skills that are outside the general scope of his rating

1-22. On being transferred, what step should you take with regard to your Record of Practical Factors, NAVEDTRA 1414/1 form?
1. See that it is removed from your service record and destroyed
2. See that it is in your service record before you transfer
3. Have your division officer make appropriate entries in the date and initials columns for factors not checked off
4. Have your personnel office make appropriate entries in the date and initials columns for factors not checked off

1-23. Which training publications listed in the Bibliography for Advancement Study, NAVEDTRA 10052 (current edition), for the Construction Mechanic rating must you complete before you are eligible to take the applicable CM1 or CMC servicewide examination for advancement?
1. All publications listed for the CM rating
2. Basic Rate Training Manuals listed for the CM rating
3. Asterisked Rate Training Manuals listed for E-6 and E-7
4. All publications listed for E-4 and E-5

1-24. One of the purposes of Rate Training Manuals is to
1. aid personnel in the preparation for advancement
2. provide ready study references for specific equipment
3. supplement the study material of personnel in Navy schools
4. provide current information to personnel in the fleet

In items 1-25 through 1-27, select from column B the publication that contains the information in column A.

	A. Information	B. Publications
1-25.	Military and occupational knowledge factors needed to perform duties of a rating	1. Military Requirements for Petty Officer 3 & 2
1-26.	Required and recommended references that concern military qualifications	2. Bibliography for Advancement Study
1-27.	Current edition of the training manual related to the occupational qualifications of a rating	3. List of Training Manuals and Correspondence Courses
		4. Manual of Qualifications for Advancement

1-28. By taking the applicable nonresident career course, you help teach yourself the subject matter in a Rate Training Manual.

1-29. The Index of Naval Facilities Engineering Command Publications lists in alphabetical and numerical order publications of interest to personnel in Group VIII ratings.

1-30. Before showing training films to trainees you should make it a practice to
1. cut all obsolete material from the films
2. check the films for up-to-date information and accuracy of procedures
3. use only those films that contain no obsolete information

Learning Objective: Identify basic principles of supervision. Textbook pages 8 and 9.

1-31. A high level of production indicates good supervision only when it is accomplished willingly and with interest on the part of the working crew.

1-32. All the following are common mistakes of a new supervisor EXCEPT
1. using "new broom" tactics
2. asserting authority to attract attention
3. teaching his men what not to do
4. playing favorites

1-33. Upon assuming duties as a supervisor, what should a CM1 or CMC do?
1. Make it clear that all things will be changed
2. Tell his men that foolishness will no longer be tolerated
3. Tell his men that he intends to leave things as they are for the present
4. Indicate to his men that he will do something about any gripes they have

1-34. As a new supervisor on the job, a CM1 or CMC will be able to keep matters better in hand by
1. trusting none of his subordinates
2. letting his men know that he is not going to be responsible for any of their mistakes
3. immediately letting his men know who is boss and that his orders will not be questioned
4. accepting full responsibility for anything that takes place on the job

1-35. Which of the following practices should a supervisor observe in building the proper relationship with his men?
1. Make clear by his actions that he considers himself a step above his men
2. Have answers for everything and make it clear that he does not need suggestions from his men
3. Be a regular guy with his men, both on and off the job
4. Maintain a friendly conservative manner, be consistent, demonstrate confidence in his men, and set a good example

1-36. Which of the following is a good practice for all supervisors?
1. Caring for tools and equipment
2. Training or developing subordinates
3. Delegating no authority to subordinates
4. Disregarding suggestions by subordinates

Learning Objective: Designate the logs, records and reports designed and used by Construction Mechanic supervisors for recording information related to daily work activities. Textbook page 10.

In items 1-37 through 1-42, select from column B the log or record on which to enter the information in column A.

	A. Information	B. Logs or Records
1-37.	Work that is accomplished by your shop	1. Work Progress Log
1-38.	Status of work currently being performed by indigenous personnel	2. Daily Man-Hour Report
1-39.	Brief description of any uncompleted job and the date the shop order was received	3. Material Expended Record
1-40.	The shop order on which you have used certain materials and the amount of materials that you have on hand	4. Equipment Log
1-41.	Location of a portable tool	
1-42.	Shop repair numbers, unit requesting the job, brief description of the job, total number of man-hours required to complete the job	

Learning Objective: Point out techniques of training and developing subordinates. Textbook pages 11 through 13.

1-43. Success in setting up a training program for developing the skills of your men will depend on which of the following factors?
1. Policies of the command
2. Training facilities available
3. Directives from higher authorities
4. Each of the above

1-44. In developing your men, you should NOT only hold each platoon leader responsible for the men in his platoon, but hold him responsible for
1. supervising their on-the-job training
2. supervising their military training
3. training them for advancement
4. doing all the above

1-45. Assume you are assigned the task of planning and scheduling a training program for improving the skills of men assigned to a given construction project. Which of the following is a recommended practice?
1. Never undertake training when there is an actual construction job to be accomplished
2. Do not schedule construction until thorough training has been achieved
3. Consider the demands of both training and construction, placing emphasis on the training when a conflict arises
4. Consider the demands of both construction and training, giving priority to the completion of essential construction operations

1-46. Your battalion has been assigned a special project and your company commander tells you to develop a training program for your men. One of the steps you should take in developing the program is to find the
1. unusual conditions involved in the project
2. priority of the jobs involved in the project
3. skills possessed by each man
4. skills required to carry out the various jobs

1-47. To be effective in teaching a group of trainees, the first thing you should do is to
1. write a good lesson plan
2. decide what to teach and how much to teach at one time
3. select suitable training aids
4. divide the group into smaller units

1-48. In preparing to train your men to do a job, you can reduce your chances of omitting important steps from the job process by
1. taking an inventory of skills required for the job
2. developing a written lesson plan
3. conducting a PRCP interview
4. taking a refresher course in on-the-job training

Learning Objective: Indicate techniques of implementing a battalion safety program at the company level. Textbook pages 14 and 15.

1-49. The safety officer is responsible for formulating safety doctrine and policy for the battalion. He does so by which of the following means?
1. Conducting on-the-job analyses
2. Investigating and reporting all accidents
3. Consulting with project managers and section leaders
4. All of the above

1-50. How often should you hold a standup safety meeting in your shop?
1. Weekly
2. Biweekly
3. Monthly
4. Whenever an accident has been reported

1-51. Which of the following results should come out of a group discussion pertaining to an accident which happened in your shop and resulted in an injury?
1. Kind of injury sustained
2. Ways of preventing the accident
3. Cause of the injury
4. All the above

1-52. Regularly scheduled standup safety meetings must be kept interesting. You can help keep them from becoming dull by
1. letting your men air their gripes at the meetings
2. exceeding the time limits you set for the meetings
3. having the same man conduct all the meetings
4. showing good motion pictures and other visual aids on suitable subject matter

1-53. Shop safety should be a chief concern of all hands working in an area. Which, if any, of the followir conditions should you overlook while inspecting the work area?
1. Inadequate lighting and ventilation
2. Missing safety devices
3. Insufficient firefighting equipment
4. None

1-54. All discrepancies that you find during an inspection must be corrected after your report is submitted to the safety officer.

Learning Objective: Explain the procedures used by the supervisor for reporting accidents occurring in a shop, an office, or within his crew. Textbook pages 15 through 19.

1-55. In case of an accident in your shop, you must write answers to the questions on OPNAV Form 5100/1.

● Refer to figures 2-2 through 2-5 of your textbook when answering items 1-56 through 1-60.

1-56. The instructions furnished with the accidental Injury/Death Report (OPNAV 5100/1) should be used in
1. summarizing safety lectures and movies that focus on accident prevention
2. recommending actions that will help prevent accidents similar to the one being reported
3. investigating and reporting circumstances that surround the accident
4. organizing a training program that will emphasize accident prevention

1-57. What block contains information pertaining to the means by which ANDERSON came in contact with the source of his injury?
1. 17
2. 18
3. 21
4. 22

1-58. What block contains information pertaining to the circumstances and events that caused ANDERSON to fall?
1. 17
2. 18
3. 21
4. 22

1-59. What block contains information pertaining to the condition that caused or contributed to ANDERSON's accident?
1. 17
2. 18
3. 21
4. 22

1-60. What block describes the nature of ANDERSON's injury?
1. 17
2. 18
3. 21
4. 22

1-61. The purpose for filling out sections 22 through 25 of the Accident Injury/Death Report (OPNAV 5100/1) is to
1. recommend corrective action
2. identify the principal unsafe condition or act that caused the accident
3. provide a detailed description of the accident
4. determine whether or not a formal investigation of the accident is required

1-62. Block 27 of the Accident Injury/Death Report (OPNAV 5100/1) should include
1. your description of the accident
2. your opinion as to whether or not the accident was caused by an unsafe act
3. your opinion as to whether or not the accident was caused by an unsafe condition
4. actions taken or recommended to be taken to prevent recurrence of an injury similar to the one being reported

In items 1-63 through 1-66, select from column B the classification given to the condition or action in column A when found to have caused, permitted or contributed to an accident.

	A. Conditions or Actions	B. Classifications
1-63.	Allowed water, oil, or grease to accumulate on a working surface	1. Unsafe condition
1-64.	Injured person did not understand that he was required to wear goggles while grinding	2. Unsafe act
1-65.	Hammered on chisel that has a mushroomed head	3. Unsafe personal factor
1-66.	Mixed battery acid and water without wearing protective gear	

1-67. What is the main reason for completing the investigation of an accident involving an injured crewmember?
1. To assign responsibility for the accident to the proper individual
2. To determine the amount of liability for the accident that the crewmember should properly assume
3. To prevent accidents of a similar nature
4. Each of the above

Assignment 2

Supervision, PW Transportation Shops Supervisor, and Battalion Equipment Company Shops Supervisor

Textbook Assignment; NAVEDTRA 10645-E: Pages 20-39

Learning Objective: Indicate the purpose of the Personnel Readiness Capability Program and skill classifications associated with the program. Textbook pages 2-20 through 2-25.

2-1. The purpose of the Personnel Readiness Capability Program is to provide accurate up-to-date personnel information that will enable the NCF to
1. schedule day-to-day work assignments for individual crewmembers
2. to combine all the information relevant to the planning and scheduling of project functions into a single master plan
3. increase its capabilities to plan, make decisions, and control

Use the following alternatives when answering items 2-2 through 2-6.
1. Individual General Skills
2. Individual Rating Skills
3. Military Skills
4. Crew Experience (Skills)

2-2. Skills related to two or more ratings which are primarily nonmanipulative are classified as

2-3. Skills you acquired as a result of working with others on a particular project are normally classified as

2-4. Skills you acquired as a result of training for combat are broadly classified as

2-5. Nontechnical skills you acquire by participating in a cross-rate training program are generally classified as

2-6. Technical skills specifically related to one of the Construction ratings are classified as

2-7. If you collect any information through observation or interview concerning an individual's skills, you must send it to FACSO, Port Hueneme on
1. an IBM card
2. a Transcript Master form
3. a message form
4. a 3 x 5 card

2-8. If you are in doubt about the proper methods to use in processing PRCP data, you should check with the
1. Public Works Officer
2. Security Officer
3. Chief Staff Officer
4. Training Officer

2-9. Before conducting an individual rating skill interview, what must you do?
1. Review the appropriate section of the Quals Manual
2. Prepare an interviewee's service record
3. Prepare an interviewee's checkoff sheet
4. Learn as much as you can about the skills and tasks explained in the interviewing guides

2-10. Refer to textbook figure 2-6. As a supervisor, which task or tasks must you interview a man for to see if he is qualified to skill level 3?
1. Test cylinder compression
2. Test, clean, and adjust pollution control systems
3. Conduct engine test with a dynamometer
4. Both tasks 1 and 2

2-11. How many skill levels are there for the skill definition given in textbook figure 2-7?
1. 1
2. 2
3. 3
4. 4

2-12. A typical task analysis with task elements and related action statements is illustrated in textbook figure 2-8. What is the interviewee's possible score?
1. 68
2. 48
3. 40
4. 38

● Items 2-13 through 2-16 are to be judged true or false. Assume you are an PRCP interviewer and are interviewing men for a particular skill level.

2-13. You should explain the purpose of the interview to each interviewee.

2-14. You should explain to each interviewee that he should not be embarrassed if he does not know everything that is expected of him about a specific skill level.

2-15. You should stimulate the interest of each interviewee by asking him questions pertaining to related tasks not listed in the guides.

2-16. You should score the results of each task immediately and, if time permits, recommend how your interviewee can improve his techniques or knowledge.

2-17. You are discussing the tasks element: evaluate readings. Which action statements in textbook figure 2-8 will the interviewee be held responsible for?
1. A, B, and F
2. A, B, and G
3. A, C, and D
4. A, C, and T

● Information for items 2-18 and 2-19. After completion of the task interview for task 332.1.01, shown in textbook figure 2-8, points were awarded to the interviewee for the task elements as follows:
.01 - 14 points
.02 - 21 points
.03 - 21 points
.04 - 6 points

2-18. The total value of the points awarded to the interviewee indicates that he should be certified as qualified in the task.

2-19. Assume your interviewee was awarded enough points to qualify for the next skill level. He still needs to increase his knowledge concerning the
1. tools and equipment for testing cylinder compression
2. sequence in which the steps for cylinder compression tests should be performed
3. parameters of taking recording, and evaluating cylinder, compression readings
4. techniques of removing spark plugs

Learning Objective: Explain the procedures used to check personnel out on Practical Factors. Textbook page 26.

2-20. Your crewmembers are entitled to take the servicewide examination for advancement without first qualifying in the practical factors of both the military qualifications and the occupational qualifications

2-21. When training a group of men for advancement-in-rate, what action should you take as each man demonstrates his ability to perform certain practical factors?
1. Report the accomplishment to the commanding officer
2. Make a report to the training officer
3. Record the fact on a form 1414/1
4. Record the fact on a certificate of completion

2-22. When the work situation does not allow a crewmember to demonstrate his ability to perform a given practical factor, what action, if any, should you take.
1. Devise a practical factor performance test
2. Devise a knowledge factor performance test
3. Make an appropriate entry in his service record
4. None

Learning Objective: Recognize basic work practices of a Public Works transportation maintenance shop. Textbook page 28.

2-23. With which of the following personnel will you maintain contacts in your work as PW transportation shop supervisor?
1. Mechanic
2. Military and civilian operators of equipment
3. Officers to whom you are responsible
4. All the above

2-24. The foreman in a PW transportation shop must be a U.S. Civil Service employee.

2-25. The duties of the foreman in a PW transportation maintenance shop and those of the supervisor of a construction battalion equipment maintenance shop are similar.

2-26. Which of the following statements best describes the work of a Public Works Transportation maintenance shop?
1. The bulk of the work is of a one-time nature
2. Much of the work is of a continuing nature
3. The work is usually done by military personnel
4. Work methods are the same as those used in a battalion equipment maintenance shop

2-27. Civil Service personnel are employed in a PW transportation shop to provide
1. jobs for the civilian community
2. experienced personnel who can be drafted in the event of war
3. continuity of service

Learning Objective: Explain the operation and organization of a Public Works Transportation Department. Textbook page 28.

2-28. The location of shop tools and equipment will depend on the amount and the type of equipment to be maintained in your maintenance shops.

2-29. The organization of a typical PW transportation department includes which of the following divisions?
1. Equipment operations
2. Production control
3. Equipment maintenance
4. All the above

2-30. To what division of a PW transportation department is a CM1 or a CMC normally assigned?
1. Equipment operations division only
2. Production control division only
3. Equipment maintenance division only
4. Either production control or equipment maintenance division

Learning Objective: Point out the duties and responsibilities of supervisory personnel of a Public Works Transportation Department. Textbook pages 29 through 31.

2-31. Who functions as a technical advisor in planning equipment required for the PW Center?
1. Equipment operations general foreman
2. Production control supervisor
3. Transportation superintendent
4. Equipment maintenance general foreman

2-32. Besides being responsible for receiving, inspecting, and classifying all new and used equipment, the production control supervisor determines the
1. number of vehicles required for his activity
2. parts and tools that are needed to support this equipment during its life cycle
3. budgetary requirements for the maintenance division
4. workload for the transportation department

2-33. Scheduling the workload for the various centers of the Transportation Department is the responsibility of the
1. general foreman
2. general purpose equipment work center foreman
3. production control supervisor
4. construction and specialized equipment work center foreman

2-34. In the absence of the transportation superintendent, who assumes his duties and acts as transportation superintendent?
1. Production control supervisor
2. General purpose equipment work center foreman
3. General foreman
4. Construction and specialized equipment work center foreman

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In items 2-35 through 2-39, select from column B the supervisory personnel who is responsible for the duty in column A.

A. Duties	B. Supervisors
2-35. Supervises the tire shop, body and paint shop, and battery shop	1. Transportation superintendent
2-36. Exercises full managerial and administrative responsibility of the PU transportation activity	2. Production control supervisor
2-37. Issues and enforces safety practices and fire regulations	3. General purpose equipment work center foreman
2-38. Maintains shop backlog records and vehicle history files	4. Construction and specialized equipment work center foreman
2-39. Supervises the machine shop	

2-40. The general purpose equipment work center foreman and the construction and specialized equipment work center foreman have basically the same responsibilities. Which of these responsibilities is excepted for the construction and specialized equipment work center foreman?
1. Technical supervision of his work center
2. Analyzing and interpreting SDOs
3. Issuing and enforcing safety practices and fire regulations
4. Maintenance, repair, and major overhaul of specialized equipment

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Learning Objective: Describe the procedures used in the preservation, depreservation, and storage of equipment. Textbook page 31.

2-41. The level of preservation to apply to construction equipment depends on which of the following factors?
1. Information received as to how the equipment is to be handled, shipped, and stored
2. Conditions to which the equipment will be subjected during its storage period prior to issue
3. Physical characteristics of the equipment
4. Each of the above

2-42. All corrosion and contaminants must be removed from a piece of equipment before it is preserved.

2-43. Active storage equipment must be operated for short periods of time at regular intervals to keep it in serviceable condition.

2-44. Which of the following is NOT a step in the procedure for depreserving stored equipment before it can be operated?
1. Removing seals and closures
2. Removing preservatives with abrasives
3. Lubricating the movable parts of the equipment
4. Reinstalling the components removed for storage

Learning Objective: Explain principles and techniques of preventive maintenance for equipment. Textbook pages 32 and 33.

2-45. What is the most important phase of preventive maintenance?
1. Scheduled command inspections
2. Unscheduled inspections
3. Scheduled periodic preventive maintenance
4. Unscheduled periodic preventive maintenance

2-46. The starting point for preventive maintenance is the
1. unscheduled periodic inspection
2. scheduled command inspection
3. operator's daily maintenance
4. mechanic's minor repair

2-47. Your maintenance shop has noted that the operators are not performing proper daily PMs on their equipment. With whom should you consult to set up training periods?
1. Equipment operators
2. Equipment operation branch foreman
3. Maintenance shop inspector
4. Production control supervisor

2-48. When should your personnel inspect vehicles for safety and serviceability?
1. At the time a scheduled type A is performed
2. At intervals not to exceed six months or 6,000 miles, which ever occurs first
3. At the time a scheduled type B is performed
4. At the time a scheduled type C is performed

2-49. Which of the following points should you check during a vehicle brake inspection?
1. Brake pedal free travel
2. Brake line leakage
3. Brake drum wear
4. All the above

2-50. Which of the following items are NOT found on a motor vehicle safety inspection checklist?
1. Brakes, lights, and tires
2. Exhaust and steering system
3. Radiator and doors
4. Lights, windshield wipers, and warning devices

2-51. Tires should be removed from motor vehicles and replaced when the thickness of the tire tread is
1. 1/16 inch or less
2. 1/10 inch
3. 1/8 inch
4. 1/4 inch

2-52. In addition to safety inspections, vehicles should be inspected and serviced as
1. prescribed by the manufacturer
2. often as mechanics are available
3. little as possible to keep the cost down
4. prescribed by the dealers

2-53. Under what condition are extensive repairs to an engine authorized?
1. When the inspector determines that the engine has a malfunction
2. When the manufacturer recommends a major tuneup of the engine
3. When the operator reports engine power loss

2-54. What constitutes an unscheduled maintenance service?
1. Correcting troubles listed on the operators daily trouble report
2. Correcting additional troubles found during this service period
3. Correcting any safety deficiencies noted prior to releasing the vehicle
4. All the above

Learning Objective: Point out fundamentals of a Public Works cost control system. Textbook pages 33 through 36.

2-55. The cost control system provides a means for comparing the actual performance of maintenance work on transportation equipment to the hourly standards that are
1. derived from the machours accumulated in the use of the equipment
2. established by the equipment manufacturers and the Naval Facilities Engineering Command
3. derived from past work records
4. based upon the volume of work accomplished

2-56. Which of the following costs are charged to allotments and appropriations in the cost control system?
1. Indirect labor and material costs of equipment maintenance and operation
2. Direct labor and material costs of equipment maintenance and operation
3. Costs of building maintenance, shop stores, and utilities
4. All the above

2-57. The labor cards of textbook figures 3-2 and 3-3 are used in the cost control system for collecting
1. direct labor costs
2. indirect labor costs
3. military pay costs
4. all the above

2-58. Transportation management reports include data for comparing actual maintenance costs and standard maintenance costs.

2-59. Textbook figure 3-4 is an example of a Shop Repair Order. One use of such an order is recording
1. the cost of repairs
2. the materials used
3. the hours required to do the work
4. each of the above

2-60. The extent of the services that a PW Maintenance shop will provide in maintaining, repairing, or overhauling an activity's automotive equipment depends on which of the following factors?
1. Economics
2. Distance of the activity from commercial repair shops
3. Size of the activity
4. Each of the above

2-61. The cost of repair services by the preventive maintenance shop must be justified when the nature of the work is classified.

Learning Objective: Recognize basic principles in the organization of the equipment maintenance branch in an NMCB. Textbook page 37.

2-62. What sections constitute the equipment maintenance branch of an NMCB?
1. Administration and automotive repair sections
2. Heavy equipment repair and support sections
3. Automotive repair and support sections
4. Administrative, automotive repair, heavy equipment repair, and support sections

2-63. The equipment maintenance branch is normally under the overall supervision of a/an
1. EQCM
2. CMCS
3. Civil Service employee
4. CMC

2-64. Who normally serves as a section head in a maintenance branch?
1. EQCM
2. CMCS
3. CM1 or CMC
4. CM2

Learning Objective: Point out factors to consider in setting up a battalion maintenance branch. Textbook pages 37 through 39.

2-65. In planning for the location of a maintenance shop, you should take into consideration which of the following?
1. Nearness to transportation facilities
2. Room for expansion
3. Size of parking area
4. All the above

2-66 Name two factors you should consider in deciding what type of tools and equipment to have on hand.
1. Goals and limitations set by regiment
2. Layout of the shop and the qualifications of your mechanics
3. Operation needs of the battalion and the cost of having work performed at an overhaul facility
4. Cost plus factor and the expediency of the commercial facility

2-67. Deciding that work can be done more economically at a component overhaul facility than in the maintenance branch is based solely upon the
1. cost plus factor
2. availability of the facility
3. facts and figures in transportation maintenance management reports
4. desires and goals of the regimental transportation officer

2-68. Where should you locate drill presses, bench grinders, and other common power tools for repairing many kinds of equipment?
1. In or near the main shop area
2. In an area where ON-OFF switches are reached easily
3. In an area where water is accessible, in case of fire
4. In any section of the equipment maintenance branch

2-69. In which of the following places should you locate the master switch that controls all power in the maintenance shop?
1. A room that can be secured easily
2. A space that is in full view of all shop personnel
3. An area that can be controlled by a supervisor
4. A location that can be reached quickly in an emergency

2-70. For the sake of safety, what should you do in the area where welding equipment is used?
1. Have the area screened and equipped with firefighting equipment
2. Locate the area away from the rest of the shop areas
3. Have the area posted with hazard warning signs
4. All the above

2-71. Why should tire repair equipment be located in a separate section of the shop near one of the shop's entrances?
1. To eliminate the need for duplicate equipment
2. To enable it to be used by patrons of the hobby shop after working hours
3. To enable Civil Service employees, as well as CM's to use it
4. To allow the EO's to use it as readily as the CM's

2-72. Which of the following is a safe practice regarding the battery charging equipment in your maintenance branch?
1. Locating the equipment in a well-ventilated space
2. Installing an exhaust fan near the equipment
3. Having a water supply near the equipment
4. Each of the above

2-73. To help prevent shop accidents, a supervisor makes sure his mechanics observe good housekeeping and safe working practices.

2-74. Assume you are in charge of setting up a battalion maintenance shop that must be heated, lighted, and ventilated. You must consider the installation of
1. heaters, lights, and windows near work benches
2. electrical outlets for extension lights
3. fans in roof openings
4. all the above

2-75. Doors at the front and rear of the shop and windows that can be opened will normally enable enough air to enter the shop and remove exhaust gases.

Assignment 3

Battalion Equipment Company Shops Supervisor

Textbook Assignment, NAVEDTRA 10645-E: Pages 39 - 53

Learning Objective: Identify fundamentals of shop organization and responsibilities of the battalion maintenance supervisor and his subordinates. Textbook pages 39 through 41.

3-1. Who has overall responsibility for ensuring proper maintenance and repair of all automotive, construction, and materials-handling equipment assigned to a NMCB?
1. Maintenance supervisor
2. Automotive shop supervisor
3. Heavy equipment shop supervisor
4. Support section supervisor

3-2. What else does the shop inspector do besides determining what repair work is to be done on a piece of equipment?
1. Noting deficiencies on the SRO
2. Completing record forms 1149 and 1250
3. Making minor adjustments as necessary
4. Performing the next scheduled PM inspection

3-3. The automotive repair supervisor has direct control and supervision over the personnel in his section. His other duties include all the following EXCEPT
1. providing technical leadership
2. providing the field maintenance crew
3. maintaining records and reports
4. ensuring timely and quality work performance

3-4. In what situation is it worthwhile for the heavy equipment repair shop supervisor to shortchange himself as to shop personnel?
1. When furnishing additional personnel to the support section
2. When providing experienced field maintenance mechanics
3. When providing technical assistance to the logistic section with regard to repair parts

3-5. Who is responsible for furnishing the tools and equipment that the field mechanics require?
1. Senior mechanic
2. Automotive shop supervisor
3. Heavy equipment shop supervisor
4. Maintenance supervisor

3-6. The heavy and automotive repair shops that are responsible for maintaining all battalion equipment are supported by the shops of the support section.

3-7. Suppose a repair shop mechanic needs to use a tool not already in his custody. How does he obtain this tool?
1. By giving the tool issue room personnel his assigned job order number
2. By presenting an EWO to the toolroom personnel
3. By checking it out from the toolroom on a tool chit

In items 3-8 through 3-12, select from column B the rating of the person who normally mans the support shop in column A.

	A. Support Shops	B. Ratings
3-8.	Electrical shop	1. CM
3-9.	Chassis, body, fender, and radiator shop	2. HT or SW
		3. CE
3-10.	Battery shop	4. MR
3-11.	Tire shop	
3-12.	Machine shop	

3-13. PM lube racks should be located a distance from other shop areas as a means of
1. making lubrication services easy to perform
2. making it easy to inspect and clean equipment
3. guarding against fire
4. providing shelter to increase PM efficiency

Learning Objective: Describe fundamentals of operator maintenance, preventive maintenance, and cost control under the battalion maintenance program. Textbook pages 41 through 47.

3-14. The basic objective of the preventive maintenance program is to
1. provide a thorough inspection of each piece of equipment
2. ensure that each piece of equipment is painted when required
3. keep records to obtain a complete history of the equipment
4. keep the equipment operating and to detect minor problems before they become major ones

3-15. Who performs organizational maintenance?
1. Shop inspectors
2. Battalion mechanics
3. Equipment operators

3-16. Organizational maintenance of equipment includes which of the following?
1. Operator and mechanic inspections
2. Daily inspections, lubrications, and adjustments
3. Mechanics weekly inspections, lubrications, and adjustments

3-17. Any defect or unsafe condition found by any Equipment Operator should be reported immediately to
1. the senior mechanic
2. the shop supervisor
3. any shop mechanic
4. the dispatcher

3-18. The Operator's Inspection Guide and Trouble Report, NAVFAC 9-11240/13 of textbook figure 4-1 is completed only when a breakdown occurs.

3-19. From a PM Report (textbook figure 4-2) the maintenance inspector can obtain information concerning
1. fuel consumption
2. services performed
3. hours of operation
4. all the above

3-20. The overhaul of equipment assemblies, subassemblies, and components is the responsibility of the maintenance shops at which level of the battalion maintenance program?
1. Organizational
2. Depot
3. Intermediate

3-21. What kind of work is included in depot maintenance?
1. Rebuild only
2. Major overhaul only
3. Major overhaul, intermediate maintenance, and organizational maintenance
4. Major overhaul and rebuild

3-22. The Equipment Operator's after-operation tasks may include participation in the PM.

3-23. What is the standard interval between PM service inspections for NCF equipment?
1. 30 working days, 1500 miles, or 100 hr
2. 40 working days, 2000 miles, or 120 hr
3. 50 working days, 2500 miles, or 140 hr
4. 60 working days, 3000 miles, or 150 hr

3-24. One step in establishing the initial standard interval between PM service inspections is to
1. group all similar types of equipment
2. group all assigned equipment into 30 separate PM groups
3. distribute all assigned equipment evenly among 40 separate PM groups
4. divide the number of pieces of equipment into the number of work days per month

3-25. Whose responsibility is it to determine whether or not the PM interval for a piece of equipment should be reduced?
1. Operator
2. Mechanic
3. Shop supervisor
4. Maintenance supervisor

3-26. When, if ever, will the standard interval between PM service inspections be extended?
1. When a shortage of mechanics exists
2. When the number of projects is excessive
3. When the number of qualified inspectors assigned is insufficient
4. Never

3-27. What type of inspection is given a piece of NCF equipment at intervals of 40 working days?
1. A
2. B
3. C
4. D

3-28. Which of the following is an interval for a type B inspection?
1. 2000 miles
2. 120 hours
3. Two consecutive type A inspections
4. Each of the above

3-29. Which, if any, of the following types of inspections calls for a change of oil and oil filters?
1. A
2. B
3. C
4. None

3-30. To ensure that the PM program is being performed as prescribed, the maintenance supervisor will review the PM Record Card file at least
1. once a month
2. every other month
3. three times a year
4. quarterly

3-31. How are the PM Record Cards maintained?
1. Alphabetically by type of vehicle
2. Numerically by type of vehicle
3. By PM group in a tickler file
4. By date of scheduled PMs

3-32. What happens to the PM Record Card for a vehicle that is transferred?
1. It is destroyed
2. It is held for 1 year then destroyed
3. It is placed in the equipment history jacket
4. It is sent to the Equipment Records Division at Port Hueneme

3-33. No further inspection is required of a vehicle after it is placed on deadline.

3-34. Assume there is deadlined equipment from which some serviceable parts have been removed. The cost of installing the requisitioned replacement parts are charged against the
1. vehicle from which the interchanged part was taken
2. deadlined equipment
3. piece of equipment on which the part failed

3-35. Which of the following is NOT an intended use of EWOs and their continuation sheets?
1. Recording the cost of repairs
2. Recording the types of repairs
3. Recording the hours required for repairs, as well as the total time that an item of equipment is out of service
4. Recording the rate of the person doing the work (experience level)

3-36. What block number on the Equipment Work Order should indicate the type of maintenance repair?
1. 16
2. 18
3. 27
4. 33

3-37. What block number on the Equipment Work Order should indicate the total funds expended for maintenance cost?
1. 18
2. 29
3. 30
4. 40

3-38. Accumulation of data from the EWOs and their continuation sheets provides information for
1. budget planning
2. determining economical life expectancies
3. predicting equipment and training requirements
4. all the above

3-39. What difference, if any, is there between the authority to perform work in the field and the authority to do work in the shops?
1. An EWO must be filled out for work in the shops but not in the field
2. An EWO must be filled out for work in the field but not in the shops
3. An EWO and an SRO must be filled out for work in the shops but not in the field
4. None

3-40. The EWO Log Sheet, textbook figure 4-6, shows the dozer received an interim repair and type B PM. What type PM, if any, is it next scheduled for?
1. A
2. B
3. C
4. None

Learning Objective: Point out factors that determine outfitting repair parts allowances for support of battalion equipment. Textbook pages 47 through 52.

3-41. The Consolidated SEABEE Allowance Lists (COSALs) establish the support for which of the following assigned types of equipment based on USN-numbered listing?
1. Vehicular
2. Materials-handling
3. Organic and augmented
4. Construction/weight handling

3-42. Repair parts allowances are normally designed to provide what percentage of effectiveness for 90 days support of vehicles or equipment in new or like new condition?
1. 100 percent
2. 90 percent
3. 80 percent
4. 75 percent

3-43. General repair type items are referenced in the COSALs as parts peculiar?

3-44. What are the respective high and low limits established for the stock items carried on the Stock Record Card of textbook figure 4-7?
1. 11 and 4
2. 12 and 1
3. 14 and 7
4. 16 and 9

In items 3-45 through 3-48, select from column B the description of the supply aid in column A.

A. Supply Aids	B. Descriptions
3-45. Summary item list	1. Repair parts which are no longer required by a previous COSAL
3-46. NAVSUP 1114	2. A printed stock record card
3-47. Delete item listing	3. An item release or receipt document
3-48. DD Form 1348-1	4. Items required by the old COSAL

3-49. Which of the following materials are contained in a prepackaged library?
1. Manufacturers' parts manuals and operators' manuals
2. History jackets for assigned equipment
3. Technical manuals and shop manuals
4. All the above

3-50. Which of the following data blocks of textbook figure 4-9 should indicate that a repair part was issued?
1. R
2. D
3. C
4. H

3-51. Which of the following forms is used as authorization for drawing or ordering repair parts?
1. NAVSUP 1250
2. NAVFAC 112110/4
3. NAVDOCK 1250
4. DD 120

3-52. After the Storekeeper in the repair parts section issues the requested part, he attaches the yellow copy of the 1250 to the EWO.

3-53. Who authorizes placing on order a part which is NOT in stock and assigns a priority to the requisition?
1. Shop supervisor
2. Shop inspector
3. Senior mechanic
4. Maintenance supervisor

3-54. What action, if any, does Cost Control take when parts are being placed on requisition?
1. Assigning a department order number for each part not in stock (NIS)
2. Assigning a department order number for each group of similar items
3. Assigning a department order to each part ordered
4. None

3-55. During an overseas deployment, the repair parts section ordered the raincap shown on the repair parts summary sheet (textbook figure 4-10). How many days should be allowed for delivery of the raincap to the parts department or for a status report on the requisition?
1. 8
2. 15
3. 20
4. 45

3-56. A repair parts summary sheet is maintained for parts pending action for each
1. requisition
2. part type
3. part
4. item of equipment assigned

3-57. The supply section normally forwards DD Form 1348-1 to cost control upon receipt of ordered parts. What does the cost control clerk do?
1. Store the parts in the DTO bin or issue the parts
2. Fill in the receiving date on the repair parts summary sheet and attach DD Form 1348-1
3. Complete blocks 20 through 23 on the EWO
4. All the above

Learning Objective: Indicate procedures for conducting the Battalion Equipment Evaluation Program. Textbook pages 52 and 53.

3-58. When does the Battalion Equipment Evaluation Program (BEEP) establish uniform procedures that are to be carried out?
1. During a battalion's on-site relief and equipment turnover
2. During the original equipping of a battalion before an overseas assignment
3. At an inspection conducted three months after the battalion arrives at a station
4. At each of the above times

In items 3-59 through 3-64, assume that Naval Mobile Construction Battalion 40 is scheduled to be relieved by Naval Mobile Construction Battalion 133. Match the task in column A by selecting from column B the battalion(s) responsible for accomplishing the task during the BEEP.

A. Tasks	B. Battalions
3-59. Reviewing maintenance correspondence not yet acted upon	1. NMCB 133
3-60. Notifying higher authority of BEEP commencement date	2. NMCB 40
3-61. Providing tools and shop equipment for evaluation and repair of equipment	3. NMCB 133 and NMCB 40
3-62. Coordinating the scheduling of equipment for inspection	
3-63. Conducting a PM inspection of equipment attachments	
3-64. Inventorying all shop equipment	

3-65. Who is responsible for ensuring that an EWO, a copy of the equipment evaluation inspection guide, and a copy of the attachment evaluation inspection guide are prepared for each piece of equipment being BEEPed?
1. NMCB 133 only
2. NMCB 40 only
3. NMCB 40 or NMCB 133
4. The COMCBPAC/COMCBLANT representative

3-66. At what PM level, if any, is nonpreserved equipment inspected during the BEEP?
1. A
2. B
3. C
4. None

3-67. During the BEEP, a preserved item of assigned USN-numbered equipment is depreserved for testing after a visual inspection shows major discrepancies.

3-68. What code is given to a piece of deadlined equipment to indicate that its repairs would cost more than 40 percent of its acquisition cost?

1. R4
2. R3
3. E4
4. X1

3-69. COMCBPAC/COMCBLANT Instruction 4040.1 series contains guidelines for accomplishing the repair parts portion of the BEEP.

Assignment 4

Engine Overhaul

Textbook Assignment, NAVEDTRA 10645-E: Pages 57 - 77

Learning Objective: Define types of horsepower and measure or compute each type. Textbook pages 57 through 59.

4-1. What is the horsepower equivalent of 66,000 foot-pounds of work per minute?
1. One
2. Two
3. Three
4. Four

4-2. How many foot-pounds of work per minute can a 6-horsepower engine produce?
1. 50,000
2. 66,000
3. 100,000
4. 198,000

4-3. The horsepower of an engine can be computed mathematically or measured mechanically.

4-4. What kind of horsepower would an engine deliver if it were possible to eliminate all frictional losses?
1. Friction
2. Indicated
3. Drawbar
4. Brake

4-5. What kind of horsepower measures the actual power produced by an engine?
1. Brake
2. Drawbar
3. Indicated
4. Friction

4-6. Which of the following meters is used to measure brake horsepower accurately?
1. Viscosimeter
2. Calorimeter
3. Dynamometer
4. Ohmmeter

4-7. The mechanical braking device of textbook figure 5-1 is known as a
1. prony brake
2. chassis dynamometer
3. platform brake-testing machine
4. bench-type brake-testing machine

4-8. By definition, the friction horsepower of an internal combustion engine is the difference between
1. indicated horsepower and brake horsepower
2. indicated horsepower and belt horsepower
3. drawbar horsepower and indicated horsepower
4. taxable horsepower and drawbar horsepower

4-9. An engine drives a belt pulley through a gear train. The belt horsepower added to power lost through gear friction is practically equal to
1. brake horsepower
2. rated engine power
3. friction horsepower
4. drawbar horsepower

Learning Objective: Apply graphs and diagrams to describe engine performance and operation. Textbook pages 59 through 63.

● In answering items 4-10 through 4-12 refer to textbook figures 5-2 and 5-3.

4-10. What is the approximate brake horsepower difference, if any, of the 6-cylinder diesel engine running at 2000 rpm and a 6-cylinder gasoline engine running at the same speed?
1. 70
2. 68
3. 2
4. 0

4-11. Approximately how much fuel does a 6-cylinder gasoline engine consume in running at 1500 rpm for 1 hour?
1. 5 lb
2. 15 lb
3. 28 lb
4. 32 lb

4-12. About how much fuel does a 6-cylinder diesel engine consume in 1 hour while running at 2750 rpm?
1. 20 lb
2. 42 lb
3. 50 lb
4. 65 lb

● Refer to figure 5-4 and 5-5 of your textbook in answering items 4-13 through 4-16.

4-13. What effect, if any, does an increase of engine speed above rated speed have on the torque produced?
1. Torque drops
2. Torque rises
3. None

4-14. In which of the following speed ranges does engine torque increase steadily?
1. 1200 to 1600 rpm
2. 1600 to 2000 rpm
3. 2000 to 2400 rpm
4. 2400 to 2800 rpm

4-15. In which of the following speed ranges is engine torque falling while horsepower is rising?
1. 1000 to 1700 rpm
2. 1800 to 2000 rpm
3. 2700 to 2900 rpm

4-16. At what speed, relative to rated speed, is engine horsepower maximum?
1. About 200 rpm less than rated speed
2. Rated speed
3. About 200 rpm greater than rated speed
4. About 500 rpm greater than rated speed

4-17. Which of the following events in the cycle of gasoline operation must be timed properly to ensure correct engine timing?
1. Opening of intake and exhaust valves
2. Closing of intake and exhaust valves
3. Spark ignition of the fuel
4. Each of the above

4-18. To determine all timing events in a four-stroke cycle diesel engine, how many clockwise revolutions must you trace on the timing diagram of textbook figure 5-6?
1. One
2. Two
3. Three
4. Four

4-19. Refer to textbook figure 5-6. When does the intake valve of a 4-stroke cycle diesel engine open?
1. A few degrees before TDC as the piston near the end of its exhaust stroke
2. A few degrees after TDC as the piston nears the end of its exhaust stroke
3. Just as the piston reaches TDC on its exhaust stroke
4. At 40° before TDC as the piston nears the end of its compression stroke

4-20. What stroke of a 4-stroke cycle diesel engine begins slightly before TDC, continues through BDC, and ends during the next upstroke of the piston?
1. Power
2. Exhaust
3. Intake
4. Compression

4-21. Refer to the timing diagram of textbook figure 5-7. What is the relationship between fuel injection timing and piston position?
1. When the piston is at TDC, fuel is about to be injected
2. When the piston is at TDC, fuel has already been injected
3. When the piston is at TDC, fuel is being injected
4. When the piston is at BDC, fuel is being injected

4-22. For how many degrees past TDC does a piston in a typical General Motors 2-stroke cycle diesel engine deliver power to the crankshaft?
1. 17.5°
2. 44.5°
3. 92.5°
4. 132°

4-23. Intake air must be forced into the cylinders of a 2-stroke cycle diesel engine.

4-24. Refer to the cylinder engine diagrams of textbook figure 5-8. For what engine does a new power stroke start every 120 degrees of crankshaft rotation and last for four-fifths of a stroke?
1. 8-cylinder engine
2. 6-cylinder engine
3. 4 cylinder engine
4. 1-cylinder engine

Learning Objective: Recognize principles and techniques of diagnosing engine malfunctions. Textbook pages 65 through 69.

4-25. Which of the following malfunctions can cause an engine to lose power?
1. Incorrect ignition timing
2. Excessive vacuum spark advance
3. Worn distributor cam
4. All the above

4-26. Suppose the trouble with a diesel engine has been located inside a fuel injector. Who should get the task of repairing this injector?
1. Any mechanic who volunteers to do the task
2. Any experienced mechanic who has been trained to repair injectors
3. A qualified automotive engineer

4-27. Which of the following factors are related directly to the working parts of a diesel or gasoline engine and the capacity of the engine to produce its rated power?
1. Pressure and temperature of intake air
2. Ignition, compression, and carburetion
3. Quality of fuel and heat of compression
4. All the above

4-28. Which of the following factors do NOT relate directly to the working parts of a diesel or gasoline engine but can contribute to loss of engine power?
1. Number of accessories or attachments operated by the engine
2. Pressure of intake air
3. Temperature of intake air
4. Each of the above

4-29. Which of the following is a means of locating the source of trouble in a gasoline engine?
1. Examining engine exhaust gases
2. Operating the engine under load
3. Shorting out spark plugs
4. Each of the above

4-30. Assume a vehicle operator brought his rig into your shop after noting a bluish tinge in the exhaust gas. Also, he reports no noticeable oil leaks though oil has had to be added to the crankcase to maintain proper oil level. Which of the following is the most likely reason the engine is consuming oil?
1. Oil is being pumped out of the crankcase faster than in it
2. Oil is being burned in the combustion chambers of the engine
3. The viscosity of the oil being added to the crankcase is too low
4. Pressure of the oil being pumped through the engine is too low

4-31. Which of the following causes of excessive oil consumption by an engine is likely to result in a major engine overhaul?
1. A cracked vacuum pump diaphragm
2. Worn valve guides or stems
3. Worn piston rings or cylinder walls
4. Each of the above

4-32. A vehicle operator reports on his trouble card that his vehicle oil pressure gage shows a continuous low oil pressure reading. Which of the following engine problems could be indicated by the low reading?
1. Worn oil pump
2. Worn engine bearings
3. Weak relief-valve spring
4. Each of the above

In items 4-33 through 4-35, select from column B the method for locating the engine noise in column A.

A. Engine Noises	B. Methods
4-33. Valve and tappet clicking	1. Short out spark plugs one at a time while engine is floating
4-34. Piston-pin knocking	2. Short out spark plugs one at a time while engine is idling with advanced spark
4-35. Connecting rod pounding	3. Insert feeler gage while engine is idling

4-36. Suppose a heavy, dull, metallic knock is heard regularly while an engine is operating under load or is accelerating. Which of the following engine noises is indicated?
1. Piston-pin knock
2. Crankshaft knock
3. Main bearing knock
4. Piston slap

4-37. Which gage or tester will enable a mechanic to check the uniformity of pressures within the combustion chambers of an engine?
1. Vacuum gage
2. Compression gage
3. Cylinder leakage tester
4. Exhaust gas anlyzer

● In items 4-38 and 4-39, assume that the alternatives are compression gage readings for cylinder numbers 1 through 6, respectively.

4-38. Which set of readings for a 6-cylinder gasoline engine indicates that it is probably operating normally?
1. 83, 104, 100, 80, 92, 103
2. 99, 102, 100, 104, 101, 98
3. 101, 101, 101, 72, 100, 94
4. 103, 104, 102, 93, 99, 80

4-39. Which set of readings for a 6-cylinder gasoline engine indicates that the cylinder head gasket is probably leaking or blown?
1. 100, 102, 83, 84, 101, 103
2. 103, 100, 99, 101, 101, 102
3. 82, 103, 103, 100, 87, 101
4. 101, 101, 101, 97, 100, 103

4-40. A mechanic obtains information about the internal condition of a gasoline engine by watching the way the vacuum gage pointer acts while gage readings are being taken.

4-41. In what range should a vacuum gage reading fall for a gasoline engine in good condition idling at 550 rpm at a 4,000 foot altitude?
1. 21 to 26 inches
2. 17 to 22 inches
3. 15 to 20 inches
4. 13 to 18 inches

4-42. Assume you are measuring the vacuum of an engine that is in good operating condition. At idle speed, the gage reading is 22 inches. How should the gage pointer act when the throttle is opened and closed suddenly?
1. Hold steady at 22 inches
2. Fluctuate between 21 and 23 inches
3. Drop to 20 inches, rise to 24 inches, then steady out at 22 inches
4. Rise to 24 inches, drop to 20 inches, then steady out at 22 inches

4-43. A vacuum gage may indicate an incorrect adjustment of the idle speed screw on a carburetor. Describe the behavior of the gage pointer in this case.
1. It remains steady on 10 inches
2. It remains steady on 18 inches
3. It varies slowly between 13 and 15 inches
4. It varies rapidly between 13 and 19 inches

4-44. A mechanic locates compression leaks within an engine under simulated conditions by conducting which of the following tests?
1. Compression test
2. Vacuum test
3. Cylinder leakage test
4. Any of the above

4-45. A device for introducing compressed air into the cylinder of an engine can be made by removing the insulator from an old spark plug and welding a pneumatic valve stem to the threaded end of the plug.

4-46. When using compressed air to test an engine cylinder for leakage, you notice air bubbles in the radiator coolant. The bubbles indicate that air is probably being released through a
1. defective head gasket
2. leaking intake valve
3. defective exhaust valve
4. piston ring

4-47. A reading on the gage of the cylinder leakage tester shown in textbook figure 5-9 will indicate the
1. air pressure in a cylinder
2. percentage of air loss in a cylinder
3. air temperature in a cylinder
4. amount of carbon built up on a piston

Learning Objective: Indicate procedures for overhauling the valves, valve mechanisms, and cylinder heads of internal combustion engines. Textbook pages 70 through 77.

4-48. The overhead valves of a gasoline engine are usually adjusted cold.

In items 4-49 through 4-52, select from column B the possible cause of the trouble in column A.

A. Troubles	B. Possible Causes
4-49. Broken valve	1. Insufficient valve tappet clearance
4-50. Burnt valve	2. Rich fuel-air mixture
4-51. Sticking valve	3. Cocked valve spring or retainer
4-52. Valve deposits	4. Insufficient oil

4-53. A valve clearance less than specified by the manufacturer will result in
1. late opening of the valve
2. inadequate scavenging of the combustion chamber
3. burning of the valve and valve seat
4. loosening of the valve adjustment locks

4-54. Which condition may be directly caused by a valve that is adjusted too tightly?
1. Cocked valve spring
2. Damaged piston
3. Loose adjustment locks
4. Oil leaks

4-55. Valves that are inside the block of an engine should be adjusted while the engine is cold.

4-56. When valves are being adjusted where is the piston positioned?
1. TDC of the compression stroke
2. TDC of the intake stroke
3. BDC of the intake stroke
4. BDC of the compression stroke

4-57. Why do valve lifters of the type shown in textbook figure 5-12 provide ideal valve timing?
1. They operate at zero clearance
2. They compensate for engine temperature changes
3. They adapt automatically for minor wear at various points
4. They do all the above

4-58. When only one hydraulic valve lifter in an engine is noisy due to being dirty, the other lifters are likely to be clean and troublefree.

4-59. A mechanic should measure the eccentricity of a valve before deciding whether to reuse or replace it.

4-60. Valves and their seats are refaced at exactly the same angle to help the valves cut through carbon deposits for improved sealing.

4-61. A valve must be discarded after refacing when thickness A of textbook figure 5-14 is more than half the original thickness.

4-62. By what means is a valve seat grinder kept concentric with the valve guide during the process of grinding valve seats?
1. Upper and lower grinding stones
2. Centered grinding stones in the chuck
3. A self-centering pilot in the valve guide
4. Centrifugal force

4-63. A 70-degree grinding stone is used to narrow and center a valve seat at the bottom after it is ground at the top.

4-64. One method of checking the valve seating is to coat the valve face lightly with Prussian blue and twist the valve 1/4 turn in its seat. How can you tell whether the valve seat is concentric with the valve guide?
1. Prussian blue will transfer evenly to the valve seat
2. There will be no trace of Prussian blue on either the valve or its seat
3. The shade of Prussian blue will grow brighter
4. Prussian blue will collect in a pile on the valve seat

4-65. What is the technique for inserting a new valve seat?
1. Heat the engine block or cylinder head to expand the valve opening, then drop the insert in place
2. Shrink the insert by chilling, then drive it in place
3. Hold the insert with pliers, then tap in place with a hammer
4. Squeeze the insert with a special insert tool, then drop it in place

4-66. A mechanic removes valve guides from some L-head engines after driving the guides into the valve spring compartment.

4-67. A mechanic is checking valve guide wear in an L-head engine with a dial indicator. Which of the following steps should he omit?
1. Turn the engine over to move the valve off its seat
2. Move the valve sideways when measuring the amount of wear
3. Measure the inside diameter of the guide and outside diameter of the valve stem

4-68. When servicing valve lifters, the mechanic must remove the camshaft before he can extract the lifters.

4-69. What corrective action must be taken when the bore of a solid valve lifter becomes worn?
1. Reface the lifter, ream out the bore, then fit with an oversize lifter
2. Ream out the bore, then fit with an undersized lifter
3. Ream out the bore, then fit with an oversize lifter
4. Replace the complete valve lifter assembly

4-70. What is the signal for the end of a leak down rate test on an hydraulic valve lifter?
1. Feeler gage loosens as the valve seats
2. Feeler gage binds as the valve seats
3. Oil leaks fast as the valve seats
4. Oil leaks slow as the valve seats

4-71. Which of the following is an important step in the installation of new camshaft bearings?
1. Line reaming them before they are installed
2. Lining up the oil holes with those in the block
3. Staking them whether or not the old bearings were staked

4-72. How can you tell whether the timing gear keyed on the camshaft and the one keyed on the crankshaft are installed to ensure proper valve timing?
1. The number of gear teeth between marks is divisible by three
2. All the marks on the gear teeth fall on the same straight line
3. There is an even number of teeth between gear marks
4. The gears mesh so that the two marked teeth of one gear straddle the one marked tooth of the other gear

Assignment 5

Engine Overhaul (continued); Automotive Electrical Systems and Equipment

Textbook Assignment, NAVEDTRA 10645-E: Pages 78 - 102

Learning Objective: Describe methods of servicing the crankshaft and cylinders of an internal combustion engine. Textbook pages 78 through 80.

5-1. The usual remedy for crankshaft bearings that appear to have worn uniformly is bearing replacement.

5-2. In measuring crankshaft journals, a mechanic finds one that has worn out of round by 0.004 inch. Wear on the other journals is negligible. What should he do in this situation?
1. Regrind the out-of-round journal only
2. Regrind all the journals
3. Replace the crankshaft

5-3. The shape of flattened Plastigage that was used to check bearing clearance gives an indication of
1. excessive crankshaft endplay
2. a locked or dragging crankshaft
3. a tapered or worn crankshaft journal or bearing
4. a loose bearing cap

5-4. About how far should you rotate the crankshaft when using feeler stock to check the clearance of the main crankshaft bearing?
1. One inch in either direction
2. One-half inch counterclockwise
3. One-half inch clockwise
4. Two inches clockwise

5-5. Assume a sharp irregular knock is heard each time the clutch of a vehicle is engaged or released. The probable cause of this knock is
1. clutch plate damage
2. worn thrust bearings
3. a loose throwout bearing
4. each of the above

5-6. What corrective action can be taken when cylinder walls show some taper but not enough to warrant reboring or honing of the cylinders?
1. Fit the pistons with special compression and oil-control rings
2. Refinish the cylinders
3. Fit the pistons with additional piston rings
4. Reduce the piston size

5-7. The amount of taper and oval wear in a cylinder is measured with
1. an inside micrometer
2. a special dial indicator
3. a telescopic gage and an outside micrometer
4. each of the above instruments

5-8. The mechanic should hone the glaze on the cylinder walls when installing new rings to enable the
1. rings to seat slowly
2. pistons to travel to TDC
3. rings to seat quickly
4. pistons to travel to BDC

Learning Objective: Describe methods of fitting pistons, piston pins, and piston rings and cleaning pistons during a major overhaul. Textbook pages 80 through 82.

5-9. A ridge around the upper cylinder wall must be reamed off to keep from damaging the piston and rings as they are removed through the top of the cylinder.

5-10. In removing carbon deposits from a piston, the mechanic should scrape the piston skirts to reduce wear on the cylinder wall.

5-11. The fit of a piston in its cylinder is measured accurately by means of a/an
1. outside micrometer
2. piece of feeler stock and a spring gage
3. plastigage and a dial indicator

5-12. Floating piston pins are fitted correctly when, at room temperature, slight thumb pressure is all it takes to push them through their bushings.

5-13. If a cylinder is worn tapered, which diameter of the cylinder serves as the guide for fitting piston rings?
1. Uppermost diameter of the cylinder
2. Diameter that is halfway between the top and bottom of the cylinder
3. Diameter of the cylinder through the point marking the lower limit of ring travel
4. Diameter of the bottom of the cylinder

5-14. After a piston ring is installed in its proper groove, ring clearance is checked by inserting a feeler gage between the ring and the bottom of the groove.

Learning Objective: Explain the principles of operation for alternators, rectifiers, and regulators in an a-c charging system. Textbook pages 84 and 85.

5-15. Why is the alternator preferred over the conventional generator for supplying electrical current in present day automotive equipment?
1. Its usefulness in supplying current is limited only by its size
2. It produces current that is fed to accessories without alternation
3. Its larger size enables it to supply the additional power required
4. It is small and can produce the power required for operating electrical accessories under nearly all conditions

5-16. What device enables an alternator to produce direct current?
1. Commutator
2. Rotor
3. Rectifier
4. Stator

5-17. The composition of the silicon-diode rectifier permits current to flow in two directions at the same time.

5-18. In the automotive alternator using positive and negative silicon-diode rectifiers, how many rectifiers of each type are required?
1. One positive and one negative
2. Two positive and one negative
3. Two positive and two negative
4. Three positive and three negative

5-19. How can a mechanic identify the polarity of silcon-diodes that are not marked with the plus or minus sign as shown in textbook figure 6-1?
1. Copper or silver lettering
2. Blue or green lettering
3. Black or red lettering
4. Brown or yellow lettering

5-20. Which of the following is a type of regulator for the electrical output of an alternator?
1. Transistorized
2. Carbon pile
3. Electromagnetic
4. Each of the above

5-21. The transistor regulator can be adjusted internally by
1. relocating a screw in the base of the regulator
2. turning a screw on the potentiometer
3. interchanging diode connections
4. sliding the contacts of its resistors

Learning Objective: Explain principles and techniques of troubleshooting the charging system. Textbook pages 86 through 92.

5-22. In troubleshooting a charging system the mechanic observes that the generator field coils are grounded externally at the regulator. Which type of field circuit will he be testing?
1. "A" circuit
2. "B" circuit
3. "A" or "B" circuit, depending on whether the system is positive or negative grounded

5-23. The output polarity of a d-c generator is determined by the polarity of its
1. "A" circuit
2. "B" circuit
3. permanent field pole piece
4. silcon-diode

● When answering items 5-24 through 5-33, which deal with troubleshooting a vehicle's charging system with a volt-ampere tester, refer to textbook figures 6-7 through 6-13.

5-24. Suppose that in the alternator output test, the BLUE ammeter scale indication stays at normal while engine speed is increased slowly. Which component needs replacement?
1. Alternator
2. Battery
3. Regulator

5-25. Assume that the ammeter shows no output at high voltage during a generator test and that the charging circuit is not fused at the regulator. Which component should be repaired or replaced?
1. Field lead of the wiring harness
2. Armature lead of the wiring harness
3. Regulator cutout relay
4. Generator field winding

5-26. When testing a 12-volt charging system the mechanic measures the voltage output, getting a maximum voltmeter reading of 15 volts. What is the probable cause of this output?
1. Blown fuse
2. Shorted field wire
3. Grounded field
4. Defective regulator current limiter relay

5-27. You are testing a vehicle's voltage regulator. If the voltage output is too high or too low, which of the following troubles is indicated?
1. Damaged regulator resistor
2. Faulty regulator voltage limiter
3. Burned regulator contacts
4. Each of the above

5-28. One purpose of measuring the resistance of a negative charging system circuit is to determine how much voltage is lost between the
1. generator output terminal and the negative battery post
2. generator housing and the positive battery post
3. generator output terminal and the positive battery post or between the generator housing and the negative battery post

5-29. What condition contributes to voltage drop in a circuit?
1. Open circuit
2. Excessive resistance
3. Low resistance

5-30. Excessive resistance in a vehicle's charging system can be due to
1. an open circuit
2. burned or oxidized cutout relay contacts only
3. loose or corroded connections only
4. both 2 and 3 above

5-31. Measuring the resistance of an insulated circuit is a means of isolating the cause of excessive resistance in a vehicle's charging system.

5-32. If the voltmeter reading for the test of textbook figure 6-13 is greater than 0.1 volt, there is too much resistance in the ground circuit between the regulator and generator.

5-33. In a battery drain test, the BLUE ammeter scale reading is nonzero with all the vehicle's circuits turned off. This reading is an indication of a/an
1. electrical short circuit
2. electrical open circuit
3. blown fuse
4. corroded battery ground post

5-34. Assume the mechanic is measuring the resistance of an insulated circuit in an a-c charging system. With the engine running at 2000 rpm, he should increase the load with his tester until the ammeter reading reaches
1. 24 amperes
2. 20 amperes
3. 10 amperes
4. 5 amperes

5-35. In testing the diode and stator of an alternator, the mechanic observes the ammeter scale of the volt-ampere tester.

Learning Objective: Explain principles and techniques of troubleshooting the starter system. Textbook pages 92 through 97.

● When answering items 5-36 through 5-44, which deal with troubleshooting a vehicle's starting system with a battery starter tester, refer to textbook figures 6-14 through 6-19.

5-36. When the battery starter tester is used for a quick overall test of a 12-volt starting system, which test is performed?
1. Battery starter test
2. Starting motor current draw test
3. Cranking voltage test
4. Battery switch test

5-37. Assume a vehicle is equipped with a 24-volt series-parallel starting system. Which of the following voltmeter readings is considered within normal limits for a cranking voltage test?
1. 20 volts
2. 16 volts
3. 14 volts
4. 12 volts

5-38. Which of the following is tested if the cranking voltage for a 12-volt system is 8 volts?
1. Battery capacity
2. Starter cranking current
3. Starter circuits
4. Each of the above

5-39. In a starting motor current draw test, the cranking speed of the motor is low and the current draw is normal. A check should be made of the
1. battery capacity
2. starting circuit resistance
3. starting motor cranking current

5-40. A starter insulated circuit resistance test is being performed on a 12-volt starting system. The voltage loss in each of the circuits shown in views A, B, and C of textbook figure 6-17 should NOT exceed
1. 0.2 volt, 0.3 volt, and 0.4 volt, respectively
2. 0.4 volt, 0.3 volt, and 0.1 volt, respectively
3. 0.6 volt, 0.5 volt, and 0.4 volt, respectively
4. 0.2 volt, 0.3 volt, and 0.2 volt, respectively

5-41. In tests where the engine is cranked with the ignition on, you must keep the engine from starting by connecting a jumper lead between the
1. battery posts
2. starting motor terminal and negative post of the battery
3. secondary terminal of the coil and ground
4. primary terminal of the coil and ground

5-42. What is usually indicated during a starter ground circuit resistance test if the measured voltage loss exceeds 0.2 volt or the loss given by the manufacturer's specifications?
1. Loose connection
2. Ground cable too small to carry the current
3. Dirty or corroded connection
4. Each of the above

5-43. High resistance in the circuit of the solenoid switch will, in most cases, result in increasing the current flow in the starter motor circuit.

5-44. A voltage loss of more than one volt, as measured in a solenoid switch circuit resistance test, is a sure sign of too much resistance.

Learning Objective: Describe the operating principles of the transistor, capacitor discharge, electronic, and unitized ignition systems. Textbook pages 97 through 99.

5-45. At high engine speeds, which of the following drawbacks of the conventional ignition system is overcome by the transistorized ignition system (breaker point type)?
1. Incomplete saturation of the ignition coil
2. Arcing across breaker points
3. Each of the above

5-46. Which of the following is a component of the negative-pulse transistor ignition system, replacing the breaker plate assembly of the conventional ignition system?
1. Iron timer core
2. Magnetic pickup assembly
3. Ignition pulse amplifier
4. Reluctor

5-47. One function fo the transistors in the amplifier of the magnetic-pulse transistor ignition system is to
1. control current flowing between the coil primary and ground
2. desaturate the ignition coil
3. eliminate arcing across the breaker points

5-48. Which component is connected across the primary windings of the coil in a capacitor discharge system to help assure secondary voltage output during high engine speeds?
1. Ignition pulse amplifier
2. High voltage condenser
3. Pickup coil
4. Electronic control unit

5-49. The mechanic can usually identify a capacitor discharge ignition system on a vehicle by the color of its
1. spark plug cables
2. condenser
3. coil and distributor cap
4. pulse amplifier

5-50. Of the following ignition system components, which is to be found in a conventional system as well as in an electronic (Chrysler) system?
1. Pickup coil
2. Ignition coil
3. Reluctor
4. Condenser

5-51. Induced voltage signals the electronic module of a unitized ignition system to interrupt the primary circuit.

Learning Objective: Explain principles and techniques of troubleshooting the conventional ignition system. Textbook pages 100 through 102.

5-52. In troubleshooting a conventional ignition system, the mechanic tests the primary and secondary circuits separately.

● Items 5-53 and 5-54 are concerned with troubleshooting the conventional 12-volt ignition system.

5-53. What should be the range of the voltmeter reading for an ignition switch in good condition (engine not running)?
1. 9.0 to 11.3 volts
2. 7.0 to 9.5 volts
3. 5.5 to 7.0 volts
4. 5.0 to 7.5 volts

5-54. In troubleshooting the primary circuit the mechanic should use an ohmmeter to check the condition of the
1. condenser
2. breaker points
3. ignition switch

5-55. In troubleshooting, which of the following are secondary circuit checkpoints?
1. Both coil terminals
2. Distributor contact points
3. Spark plugs

5-56. During secondary circuit testing, a spark plug cable resistance exceeds the manufacturer's recommended specifications. This condition can be caused by
1. an unseated cable at the distributor cap tower
2. spark plug cable damage
3. a defective spark plug connector
4. any of the above

5-57. To test the secondary circuit of an ignition coil the mechanic uses the low scale of an ohmmeter.

5-58. The mechanic gets a reading of 3,000 ohms when checking the secondary side of an ignition soil. This reading is an indication of
1. an open secondary circuit
2. a bad connection at either coil terminal
3. a short in the secondary turns of the coil
4. a good coil

5-59. The mechanic must be careful when checking electronic components of the breakerless ignition system since they are easily damaged by heat, shock, or reverse polarity.

5-60. While troubleshooting the breakerless transistor ignition system, the mechanic does not see a spark jump between the spark plug cable and the spark plug terminal. In sequence, what two components should he proceed to test?
1. Ignition pulse amplifier and ignition coil
2. Ignition coil and ignition pulse amplifier
3. Ignition coil and transistor
4. Transistor and ignition coil

5-61. In troubleshooting a breakerless ignition system distributor, the mechanic attaches one lead of his ohmmeter to one terminal on the distributor connector, and grounds the other ohmmeter lead. After opening the vacuum source to the distributor, he gets a finite ohmmeter reading. This reading is an indication of
1. an opening winding
2. a defective pickup coil
3. a worn center contact button

5-62. By using an oscilloscope instead of an ohmmeter and voltmeter to troubleshoot an ignition system, the mechanic can detect faults in ignition parts as they function while the engine is running.

Assignment 6

Diesel Fuel Systems

Textbook Assignment, NAVEDTRA 10645-E: Page 103 - 126

Learning Objective: Describe principles of troubleshooting and testing the injector pumps and capsule-type injector valves of the Caterpillar fuel injection system. Textbook pages 103 through 106.

6-1. The function of the capsule-type valve assembly of the caterpillar fuel injection system is to
1. time the delivery of fuel
2. meter the fuel
3. inject and atomize the fuel
4. pressurize the system

6-2. To check engine performance for faulty fuel injection, you operate the engine at a speed that accentuates the fault. The next step in the procedure is to try to get the cylinders to misfire by
1. preventing spark from reaching each cylinder
2. loosening the fuel line nut on each injector pump
3. cutting off the ignition switch
4. enriching the fuel supply to each cylinder

6-3. An injector pump should perform properly throughout the full range of rack travel when set within 0.025 inch of the full load setting of the engine.

6-4. Before the mechanic proceeds with the final stage in testing a Caterpillar fuel injector pump, he must remember to
1. siphon fuel from the pump into the collector jar
2. bleed air from the pump and collector assembly
3. inspect the injector screen filter before attaching the collector assembly

6-5. After testing an injector pump, you see that the fuel level in the collector jar is above the good range. In what condition is the pump?
1. Its plunger and barrel are worn
2. Its discharge capacity is below normal
3. Its discharge measurement is not accurate
4. It is good as new

6-6. The fuel injection test apparatus allows the mechanic to make which of the following checks on the capsule-type fuel injection valves?
1. Leakage rate
2. Spray characteristics
3. Valve opening pressure
4. All the above

6-7. Injector orifice damage inflicted when carbon deposits are wirebrushed from an injector valve could result in
1. precombustion
2. reduced power output
3. improved fuel atomization
4. no valve opening pressure

6-8. To be satisfactory, the injector valve opening pressure (as read on the test gage) should fall between
1. 100 and 200 psi
2. 200 and 300 psi
3. 300 and 400 psi
4. 400 and 800 psi

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Learning Objective: Explain the procedures for troubleshooting, disassembling, inspecting, and reassembling the Roosa Master fuel injection pump and the International Harvester fuel injector. Textbook pages 106 through 111.

In items 6-9 through 6-16, select from column B the problem that is likely to be caused by the condition in column A.

	A. Conditions	B. Problems
6-9.	Hand primer installed backwards	1. Engine idles imperfectly
6-10.	Throttle arm travel not sufficient	2. Engine starts hard
6-11.	Pump housing not full of fuel	3. Fuel not reaching pump
6-12.	One or more connector screws obstructed	4. Fuel reaching nozzles but engine won't start
6-13.	Tank valve closed	
6-14.	Governor linkage broken	
6-15.	Fuel line leaking or connected to wrong cylinder	
6-16.	Governor spring worn or broken	

6-17. Pump test readings should be taken under low idle, high load conditions.

6-18. During testing of the transfer pump, which of the following conditions will NOT cause a low pressure reading on the test gage?
1. Air leaks on the suction side of the pump
2. A restricted fuel return line
3. A malfunctioning regulator valve
4. Worn transfer pump blades

6-19. In testing for a restricted fuel supply on the suction side of the pump, the mechanic operates the engine at high idle.

6-20. During pump cleaning and inspection, it is NOT necessary to check for
1. distorted or damaged O-rings, seals, and gaskets
2. worn, distorted, or broken springs
3. opening pressure of the spray valve
4. damaged bores, grooves, and seal seats

6-21. Assume you are using the test pump of textbook figure 7-10 to check the spray valve opening pressure. The opening pressure specified for the check valve is 200 psi. Which of the following readings of the spray valve opening pressure indicates a bad check valve or seat?
1. 195 psi
2. 180 psi
3. 160 psi
4. 140 psi

6-22. After being cleaned and inspected, all injector components listed below must be lapped EXCEPT the
1. injector tip
2. check valve stop
3. injector bushing
4. check valve

6-23. Before being installed in the engine, an injector is retested for
1. leakage
2. spray angle and pattern
3. valve opening pressure
4. all the above

Learning Objective: Describe procedures for troubleshooting, testing, disassembling, inspecting and reassembling General Motors fuel unit injectors. Textbook pages 111 through 116.

6-24. In troubleshooting the GM fuel system, you learn that the fuel pump is not functioning satisfactorily. Before removing the fuel pump, you should make sure
1. there is fuel in the tank
2. the filter cover bolt is tight
3. the fuel supply valve is open
4. of all the above

6-25. The likely cause of a sticking relief valve in the fuel pump is grit or foreign matter lodged between the relief valve and its seat or bore.

6-26. Suppose an engine lacks power, runs unevenly, or stalls at idle even after its fuel pump is reconditioned. What should you suspect to be the source of trouble?
1. Restricted fuel flow
2. Faulty injector
3. Excessive vacuum pressure
4. Dirty fuel filter

6-27. The mechanic should allow to remain in service a GM injector that passes all but one of its pressure tests.

When answering items 6-28 through 6-31, select from column B the injector test that corresponds with the purpose in column A.

A. Purposes	B. Injector Tests
6-28. Determine whether or not the injector plunger and bushing clearance is satisfactory	1. Valve opening pressure test
6-29. Determine whether or not fuel leaks at the injector filter cap gaskets, body plugs, and nut seal ring	2. Valve holding pressure test
6-30. Measure the pressure at which the valve opens and injection begins	3. High pressure test
6-31. Determine whether or not lapped surfaces in the injector are sealing properly	

6-32. Which of the valve opening pressure readings given below is within the specified limits for the Needle Valve type injector?
1. 450 psi
2. 800 psi
3. 3000 psi
4. 4000 psi

6-33. During the valve holding pressure test of an injector, the opening pressure drops from 450 psi to 250 psi in 50 seconds. The drop rate is an indication of a/an
1. leak due to poor bushing-to-body fit
2. leaking valve assembly due to a damaged surface or dirt
3. loose filter cap gasket
4. injector whose lapped surfaces are sealing properly

6-34. During a high pressure test, the condition of the injector plunger and bushing is determined at the time both ports close, the injector spray decreases, and the pressure rises.

6-35. During which of the following tests are the plunger bottom helix and the lower portion of the upper helix checked visually?
1. Spray pattern test
2. Injector control rack and plunger movement test
3. High pressure test
4. Fuel output test

6-36. Which device should the mechanic use to determine whether or not the fuel output of a GM injector falls within the manufacturer's recommended limits?
1. Fuel pump and fuel collector assembly
2. GM injector tester
3. Comparator

6-37. The GM injector spray tip is normally soaked in solvent for approximately 15 minutes to loosen the
1. dirt on the outside of the tip for easy cleaning
2. carbon on the inside of the tip prior to reaming
3. carbon on both the outside and inside of the tip before disassembly

Learning Objective: Explain the procedures for troubleshooting, disassembling, inspecting, reassembling, and testing the Cummins pressure-timed fuel injection system. Textbook pages 116 through 119.

6-38. How can the mechanic, when troubleshooting a PT fuel system, often eliminate the pump as a source of trouble?
1. By checking the suction side of the pump for proper vacuum
2. By running the engine at low speed throughout the full range of rack travel and observing fuel delivery
3. By adjusting the high idle stop screw until the specified high idle speed is obtained
4. By checking manifold pressure to see that it is within specified limits

6-39. While troubleshooting the PT fuel pump on an engine, when should the mechanic measure manifold pressure?
1. Just before the governor cuts in
2. Just after the governor cuts in
3. When maximum engine speed is reached

6-40. Why, when making both manifold and suction pressure checks, should the mechanic operate the engine a minimum of 5 minutes between checks?
1. To clear his gages of excess fuel
2. To clear the pump of any restrictions
3. To clear the fuel system of air
4. To create a lag in the fuel system so that his gages will readjust

6-41. Engine power loss can result from carboning of the PT injector metering orifices. How can the carbon be removed?
1. Soaking the injector in a clean solvent
2. Wire brushing
3. Smoothing with emory cloth
4. Reverse flushing while the engine is warm

6-42. What device on the PT fuel system of a turbocharged Cummins engine aids in controlling engine smoke level?
1. Smoke arrester
2. Catalytic converter
3. Aneroid
4. Scavenging blower

6-43. The mechanic should try to determine which parts of a PT fuel pump have to be replaced before he disassembles it.

6-44. All component parts of the PT fuel pump must be replaced should a disassembly inspection show that some of them are worn.

6-45. The mechanic uses which of the following means to prevent goring of the PT fuel pump and pump parts in reassembly?
1. Spring steel lock washers
2. Flat steel washers
3. Extreme pressure lubricant
4. Torque wrench

6-46. The test stand of textbook figure 7-19 enables the mechanic to simulate operation of the PT fuel pump and measure pressure that the pump develops.

6-47. Suppose while being tested a PT fuel pump fails to develop specified manifold pressure. Which of the following conditions could contribute to the failure?
1. Air leak in the suction line
2. Closed valve in suction line
3. Fuel oil temperature higher than 100°F
4. Each of the above

6-48. You are trying to find maximum manifold pressure at full throttle of a newly rebuilt PT fuel pump. With the pump running at 1500 rpm, you should turn the
1. rear throttle stop screw
2. shims under the idle spring
3. idle spring to a new position
4. idle speed screw until the idle spring is compressed

6-49. After the PT fuel pump idle speed is set, the mechanic can change its idle pressure by
1. adding or removing shims from the idle spring
2. turning the idle speed screw
3. turning the throttle screws
4. locking the throttle in the shut-off position

6-50. The amount of fuel that a PT injector delivers to the combustion chamber will be affected by a change in
1. the fuel pressure
2. the size or shape of injector orifices
3. timing
4. each of the above

6-51. Which of the following is a bad practice in servicing a PT fuel injector?
1. Plugging the inlet and drain connection holes of the injector before mounting on the test stand
2. Cleaning injector orifices with wire
3. Dipping a solvent-cleaned injector into mineral spirits
4. Inserting a new gasket between the cup and body of the injector during assembly

Learning Objective: Point out the procedures for removing, disassembling, inspecting, and reassembling air induction system blowers, superchargers, and turbochargers. Textbook pages 120 through 126.

6-52. Superchargers and turbochargers pump a greater amount of air into an engine than could be supplied by normal atmospheric pressure. What is the effect on fuel consumption and power?
1. More fuel is burned, power is decreased
2. Less fuel is burned, power is decreased
3. More fuel is burned, power is increased
4. Less fuel is burned, power is increased

6-53. What component, if any, must be removed before a blower-equipped air induction system can be inspected?
1. Air inlet housing or air silencer
2. Flywheel housing
3. Fresh water pump
4. None

6-54. Suppose the rotors of a blower are burred but not too badly scored. What should the mechanic do in case the burrs interfere with operation of the blower?
1. Dress down the rotors after removing the blower from the engine
2. Dress down the rotors without removing the blower from the engine
3. Remove the blower from the engine and replace the rotors

In items 6-55 through 6-58 match the blower condition in column A by selecting from column B the cause of the condition.

A. Conditions	B. Causes
6-55. Inside surface of the blower housing covered with oil	1. Plugged drain tube
6-56. Rotor lobes rubbing throughout their entire length	2. Loose rotor shafts or damaged bearings
6-57. Liquid on air box floor	3. Leaking seal
6-58. Scoring between rotors and blower housing	4. Excessive backlash in blower timing gears

6-59. In removing parts from rotor shafts, a mechanic should keep from damaging the blower rotors by pulling the blower drive, driven gears, and timing gears at the same time.

6-60. After washing a blower ball bearing with cleaning solvent, the mechanic cleans the balls and races of the bearing by
1. spinning them dry with compressed air
2. directing air through the bearing and rotating it by hand
3. wiping them with a clean cloth

6-61. The mechanic replaces which of the following worn or damaged blower parts as a matched set?
1. Oil seals
2. Double row bearing
3. Timing gears
4. End plates

6-62. The mechanic should replace blower parts that an inspection shows to be worn or excessively damaged.

6-63. When is it considered necessary to change supercharger seals?
1. Only when "wet" oil appears at the ends of the rotors
2. Only when "wet" oil appears at the ends of the supercharger outlet connectors
3. Only when oil from the vapor tube shows on the rotors
4. At any time oil appears inside the supercharger housing

6-64. What should a mechanic do in case the rotors, rotor shafts, and end plates of a supercharger are cracked or broken?
1. Discard the supercharger and replace with a new one
2. Replace only the rotors and shafts; repair the end plates
3. Replace the damaged parts separately, except for the rotors and shafts which are replaced as a matched set

6-65. Under which of the following conditions is the drive coupling of the supercharger replaced?
1. Coupling pins are worn
2. Hub surface is grooved
3. Rotors and gears are not within the required tolerances

6-66. When, if ever, should engine lubricating oil be added to the gear end plate of a supercharger that is being reconditioned?
1. After it is completely reassembled but before it is installed on the engine
2. After it is completely reassembled and installed on the engine
3. Never

6-67. Which of the following conditions can cause the thrust and journal bearings of a supercharger to overheat?
1. Foreign particles in the exhaust system
2. Not enough lubricating oil
3. Foreign matter in the air induction system

6-68. Under which of the following conditions can contaminated oil damage a turbocharger because the oil filter is bypassed?
1. Oil filter is clogged
2. Turbocharger lubrication valve is open
3. Filter bypass valve is malfunctioning
4. Each of the above

6-69. A mechanic can help prevent damage to the rotary parts of a turbocharger by cleaning thoroughly the inlet and the exhaust systems of the engine.

6-70. By what means should a mechanic remove carbon deposits that still remain on turbocharger parts after they have soaked in mineral spirits?
1. Steam
2. Wire brush
3. Soft bristle brush
4. Compressed air

6-71. What part, if damaged, may require replacement of the main turbocharger main casing?
1. Exhaust casing
2. Turbine casing
3. Floating bearing

6-72. The oil seal plates of a turbocharger are replaced often since they wear out fast.

6-73. The rotor assembly of a turbocharger must be rebalanced when which of the following parts are replaced?
1. Turbine wheel and shaft
2. Sleeve and compressor wheel
3. Thrust washer and locknut
4. All the above

6-74. In mounting the turbocharger the mechanic can make sure it is in the proper operating position on the engine by locating the
1. air inlet to the right of the turbocharger vertical centerline
2. air inlet to the left of the turbocharger vertical centerline
3. oil outlet 45 degrees or more below the turbocharger horizontal centerline
4. oil outlet 45 degrees or more above the turbocharger horizontal centerline

Assignment 7

Vehicles Safety Inspections and Power Trains

Textbook Assignment, NAVEDTRA 10645-E: Pages 127 - 153

Learning Objective: Identify fundamentals of inspecting the lighting equipment of vehicles. Textbook pages 127 through 134.

7-1. The lights of a vehicle are among the items that should be inspected during a regularly scheduled PM for the vehicle.

7-2. Identification lights are usually required on which of the following vehicles?
1. Station wagons
2. Staff sedans
3. 1/2-ton pick-ups
4. 5-ton vans

7-3. How many clearance lamps does the ICC prescribe as the minimum for a truck 82 inches wide, weighing 3,500 pounds?
1. Two
2. Four
3. Six
4. Twelve

7-4. What factors are headlights tested for?
1. Beam width and remaining life
2. Output, beam deflection, and hotspot diameter
3. Remaining life and brightness
4. Candle power, aim, and focus

7-5. Suppose object A is 150 feet ahead of your jeep, object B is 300 feet ahead, and object C is 600 feet ahead. Which object or objects must you be able to see at night with properly adjusted headlights?
1. A only
2. A and B
3. A, B, and C

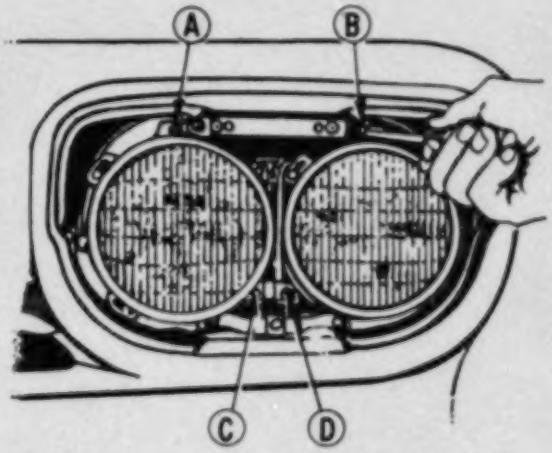

Figure 7A.--Dual sealed-beam headlight adjustment.

7-6. When adjusting the sealed-beam headlights of figure 7A, you lower the inboard headlight beam by
1. tightening screw A
2. tightening screw B
3. loosening screw A
4. loosening screw B

7-7. Tightening which adjusting screw of figure 7A allows the outboard headlight beam to swing right?
1. A or B
2. D only
3. C or D
4. C only

● When answering items 7-8 through 7-10, assume that you are using the screen of textbook figure 8-3 to aim the headlights of a passenger vehicle equipped with the 2-headlight system.

7-8. The distance between the lamp centers should be equal to
1. the distance between the floor and headlamp level on the screen
2. one-half the distance between the vehicle axis line and one of the other vertical lines on the screen
3. the distance between the vehicle axis line and one of the other vertical lines on the screen
4. twice the distance between the vehicle axis line and one of the vertical lines on the screen

7-9. If the headlamp centers of the vehicle are 28 inches above the ground, what should be the height of the horizontal reference line on the screen?
1. 23 in.
2. 25 in.
3. 28 in.
4. 31 in.

7-10. How far should the screen be in front of the headlights?
1. 3 ft
2. 10 ft
3. 12 ft
4. 25 ft

7-11. Refer to textbook figure 8-4. When aiming passenger vehicle headlights at the screen, how should you center the hotspot of the right hand lamp?
1. Sideways on line C-C, up and down the vehicle axis
2. Two inches below the left hand lamp hotspot
3. Sideways on line C-C, up and down on line A-A
4. Sideways on line B-B, up and down on line A-A

7-12. The headlight centers of an unloaded truck are 30 inches above the ground and the bright beams show on the test screen across a horizontal line that is 35 inches above the ground. How should the headlamps be adjusted, if at all?
1. Lower the beams 5 inches
2. Lower the beams 8 inches
3. Lower the beams 10 inches
4. Make no adjustment

7-13. With the aid of a screen, textbook figure 8-5, you are aiming the headlights of a vehicle equipped with a 4-headlight system. The position of the screen of the left edge of the hotspot of the outboard low beam should be between
1. straight ahead and 6 inches left of straight ahead
2. 3 inches left of straight ahead and 3 inches right of straight ahead
3. straight ahead and 6 inches right of straight ahead

7-14. Refer to textbook figure 8-7. What must the mechanic do to measure the candlepower of the headlight beam?
1. Center the hotspot of the light beam on the vertical line
2. Position the photocell to touch the glass holding the screen
3. Raise and lower the photocell to get the highest reading on the output meter
4. All the above

7-15. At night, Patrolman A is stationed along a road at a point 150 feet behind your jeep; Patrolman B is 300 feet behind your jeep, and Patrolman C is 450 feet behind your jeep. Which of the patrolmen, should be able to see your illuminated taillights?
1. A only
2. A and B
3. A, B, and C

7-16. Night Patrolman A is stationed along a road at a point 30 feet behind your jeep; Patrolman B is 60 feet behind your jeep, and Patrolman C is 90 feet behind your jeep. Which of the patrolmen should be able to read your illuminated license plate?
1. A only
2. A and B
3. A, B, and C

7-17. Patrolman A is 75 feet in front of your truck; Patrolman B is 150 feet in front; Patrolman C is 90 feet to the rear of your truck, and Patrolman D is 180 feet to the rear. Which of these patrolmen should be able to see your illuminated directional signals?
1. A only
2. A and B
3. A and C
4. A, B, C, and D

7-18. What is the minimum distance from the ground at which a directional signal unit may be mounted on the rear of a large truck?
1. 1 ft
2. 1 1/2 ft
3. 2 ft
4. 2 1/2 ft

7-19. The signals that show the widest dimension of a truck are called
1. side-marker lamps
2. identification lamps
3. clearance lamps
4. reflector flares

7-20. The signals that indicate the longest dimension of a truck are called
1. side-marker lamps
2. identification lamps
3. clearance lamps
4. reflector flares

7-21. At which height may a reflector be mounted on the back of a truck?
1. 12 in.
2. 36 in.
3. 48 in.
4. 60 in.

Learning Objective: Specify the principles of inspecting vehicle brakes and brake systems. Textbook pages 137 through 145.

7-22. At a speed of 60 mph, approximately how many feet does a vehicle travel between the time its driver sees a need for braking and the time brake pressure is first applied?
1. 44 ft
2. 55 ft
3. 88 ft
4. 186 ft

7-23. Which of the following sets of readings on the gages of a brake testing machine indicates satisfactory brake adjustment?
1. 925, 1250, 1225, 1075
2. 1325, 1450, 1025, 1075
3. 1200, 1225, 1175, 1175
4. 1150, 1200, 1275, 1150

7-24. When a vehicle's brakes are tested by the marked line method, the braking distance is measured from the line to the
1. rear of the vehicle
2. front of the vehicle
3. center of the vehicle
4. driver's seat of the vehicle

7-25. When the pedal of a hydraulic brake system is pressed down, it creeps slowly downward after about a minute. This condition could be caused by
1. a weakened brake-shoe retracting spring
2. a completely severed brake hose
3. a leaking wheel cylinder
4. ill-fitting brake shoes

7-26. Slightly out-of-round brake drums may be made true by use of a
1. boring mill
2. lathe
3. drum sander
4. router

7-27. Which of the following brake troubles is least likely to occur on a Navy truck?
1. Worn brake drum
2. Out-of-round brake drum
3. Wrong lining material
4. Greasy brake linings

Items 7-28 through 7-31 are related to the standard hydraulic brake system. Select from column B the possible remedy for the malfunction in column A.

	A. Malfunctions	B. Possible Remedies
7-28.	Pulsating brake pedal	1. Tighten backing plate
7-29.	Springy, spongy pedal	2. Tighten brake drum on hub
7-30.	Brakes chatter	3. Bleed air from lines
7-31.	Vehicle pulls to one side	4. Repair or replace wheel cylinder

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7-32. What, if anything, should happen to the pedal of a vacuum-assisted hydraulic brake system that is being held down while the engine is started?
1. Move forward
2. Move backward
3. Nothing

7-33. Which of the following conditions in a vacuum-assisted hydraulic brake system can result in hard pedal caused by vacuum failure?
1. Plugged or loose vacuum fitting
2. Collapsed or damaged vacuum hose
3. Damaged floating control valve
4. Each of the above

7-34. With the engine not running and the brakes applied, the pressure in an air brake system is 70 psi. What is the condition of the system if the pressure drops to 65 psi in one minute?
1. It is satisfactory
2. It has an air leak
3. Its compressor is defective
4. One of its relief valves is improperly set

7-35. A drained air brake system requires 8 minutes to build up a pressure of 65 psi. What is the condition of this system?
1. It is satisfactory
2. It has leaks
3. It has a defective compressor
4. Its low pressure-relief valve is set too low

7-36. Which of the following operating troubles result from a malfunction of the air-over-hydraulic power cylinder?
1. Hard pedal and dragging brakes
2. Grabbing brakes and spongy pedal
3. Low pedal and severe braking
4. Fading brakes and pulsating brake pedal

● When answering items 7-37 and 7-38, assume you are testing the power cylinder of a vehicle equipped with air-over-hydraulic brakes.

7-37. The air control pressure gage shows 60 psi and the hydraulic output pressure gage shows 1000 psi with the brake pedal fully depressed. The gage readings are an indication of
1. air leakage and hydraulic fluid leakage
2. air leakage and air trapped in the hydraulic system
3. automatic adjusters not working
4. improperly adjusted compressor governor and hydraulic pressure drop

7-38. With the brake pedal released, you get readings greater than ZERO on the air control pressure gage and both hydraulic pressure gages. These readings are an indication of
1. continuing power cylinder problems
2. dragging brakes
3. a faulty vacuum cylinder

7-39. Which of the following conditions indicates a faulty vacuum cylinder within a vacuum-over-hydraulic brake system?
1. The brake pedal moves toward the floorboard after the engine is started
2. The brake pedal moves toward the floorboard before the engine is started
3. The brake pedal fails to move before the engine is started
4. The brake pedal fails to move after the engine is started

7-40. When road testing a vehicle, you apply the emergency brake to see whether or not it is effective enough to stop the vehicle. Within what distance must the brake stop the vehicle safely when it is traveling at a speed of 20 mph?
1. 85 ft
2. 75 ft
3. 65 ft
4. 55 ft

Learning Objective: Point out fundamentals of inspecting vehicular steering systems and accessories. Textbook pages 145 through 147.

7-41. During a routine inspection of a vehicle, you notice that one tire has worn spots which allow the cord fabric to show. What should you do with this tire?
1. Reverse its position on the wheel
2. Put it on the wheel that shows the least tire wear
3. Balance it
4. Replace it

7-42. Of the following conditions, which is least likely to cause hard steering?
1. Underinflated tires
2. Improperly adjusted brakes
3. Worn universal joints
4. Loose tie-rod ends

7-43. Which of the following factors affect steering but are NOT checked in routine safety inspections?
1. Tire inflation and wear
2. Play in steering wheel and condition of front wheel bearings
3. Brake adjustment and condition of ball joints
4. Wheel camber and caster and kingpin angle

7-44. If you have tightened up the tie-rod ends of a steering system during the inspection of a vehicle, it is likely that an adjustment will have to be made to the
1. front wheel bearings
2. toe-in
3. front wheel caster or camber
4. kingpin angle

7-45. Where must the discharge point of exhaust gases be on vehicles equipped with short bodies?
1. Beyond the rear bumper
2. Behind the rear axle
3. Rear of the cab and beyond any saddle fuel tanks
4. Any of the above

7-46. On inspecting a number of vehicles, you find some windshields are cracked and some are pitted. Which windshields, if any, should be replaced before the vehicles are approved for driving?
1. The pitted windshields only
2. The cracked windshields only
3. The pitted or cracked windshields
4. None

7-47. A bus, truck, or truck-tractor must be equipped with two rearview mirrors on each side and an interior rearview mirror.

7-48. Which of the following is part of a seat belt inspection?
1. Seeing that the belts are not frayed or worn
2. Seeing that no sharp metallic object is rubbing against the cloth part of a belt
3. Making sure belt anchors are secure and tight
4. Each of the above

7-49. A horn that does not sound when being inspected should be checked for proper ground and correct voltage.

7-50. Under which of the following conditions should the kingpin lock open on a truck-tractor and trailer?
1. The operator applies the trailer brakes
2. The air release valve is activated automatically
3. The operator activates the positive release lever by hand or it is activated automatically

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Learning Objective: Describe techniques of troubleshooting an automotive clutch. Textbook pages 150 through 153.

In items 7-51 through 7-62, select from column B the type of clutch trouble that is caused by the condition in column A.

A. Conditions	B. Types of Trouble
7-51. Loose spring shackles	1. Clutch slippage
7-52. Broken pressure plate	2. Clutch drag
7-53. Excessive free pedal movement	3. Clutch grab or chatter
7-54. Worn pilot bearing	4. Clutch noise
7-55. Binding in clutch linkage	
7-56. Grease or oil on the facings	
7-57. Loose transmission mountings	
7-58. Worn engine mounts	
7-59. Binding of the friction disk hub	
7-60. Worn clutch facings	
7-61. Warped disk	
7-62. Worn throwout bearing	

7-63. In checking for a slipping clutch, you set the hand brake, start the engine, and put the transmission in low gear. In which of the following ways should you release the clutch?
1. Rapidly while accelerating the engine
2. Rapidly while maintaining constant engine speed
3. Slowly while maintaining constant engine speed
4. Slowly while accelerating the engine

7-64. When insufficient clutch pedal lash is noticed, have your mechanic check the
1. linkage adjustment
2. release bearing for wear or dryness
3. friction disk facing for surface condition

7-65. When the clutch is being uncoupled, a series of slight movements (pulsations) can be felt on the clutch pedal. The trouble indicated may be caused by which of the following conditions?
1. A warped pressure plate or warped clutch disk
2. The flywheel not seated on the crankshaft flange
3. Misalignment of the engine and transmission
4. Each of the above

7-66. Broken or weak pressure springs in the clutch plate assembly will cause the clutch disk to wear rapidly.

7-67. Which of the following practices is recommended to correct a stiff clutch pedal?
1. Oil the disk facings
2. Ride the clutch
3. Lubricate the clutch linkage
4. Adjust free travel of the pedal

Assignment 8

Power Trains (continued)

Textbook Assignment, NAVEDTRA 10645-E: Pages 154 - 173

Learning Objective: Explain operating principles of the four-speed, constant mesh, synchromesh, and auxiliary transmissions. Textbook pages 154 through 161.

● When answering items 8-1 through 8-5, refer to figure 9-4 of the text.

8-1. When the idling gear is meshed with the small contershaft gear and the large sliding gear, what gear will your four-speed transmission be in?
1. First gear
2. Second gear
3. Third gear
4. Reverse gear

In items 8-2 through 8-5, select from column B the gear position that a four-speed transmission would be in when the gears are engaged as described in column A.

	A. Descriptions	B. Gear Positions
8-2.	The forward shift or sliding gear is engaged with the constant speed gear	1. First gear 2. Second gear 3. Third gear 4. Fourth gear
8-3.	The smallest countershaft gear engages with the largest sliding gear	
8-4.	The second countershaft gear meshes with the forward slide gear	
8-5.	The largest sliding gear is disengaged and the smallest countershaft gear is in mesh with the second largest sliding gear	

8-6. Gear ratios make it possible for a vehicle to travel at different speeds even though the engine speed remains the same.

8-7. When a vehicle having a four-speed transmission is in fourth gear, the propeller shaft and the engine crankshaft rotate at a ratio of
1. 1:1
2. 1:2
3. 2:1
4. 3:2

8-8. What feature of the constant-mesh transmission enables it to operate more quietly than the old-type transmission with its spur-tooth gears?
1. Double-row spur-tooth gears
2. Helical gears
3. Main shaft meshing gears that are able to move endwise
4. Soundproof padding around the transmission case

8-9. Which component of textbook figure 9-5 enables the external teeth of the clutch gear to engage with the internal teeth of the third-speed gear of textbook figure 9-6?
1. First-and reverse-speed shifter fork
2. Countershaft
3. Third-and fourth-speed shifter fork

8-10. What advantage to the operator is the synchromesh transmission over the sliding gear type?
1. Faster gear shifting
2. Gear shifting without clashing
3. Gear shifting without losing power
4. Each of the above

8-11. What component in a synchromesh transmission equalizes the speed of the driving and driven members?
1. Friction cone clutch
2. Dog clutch
3. Shifter fork
4. Sliding sleeve

8-12. Refer to textbook figure 9-7. One function of the shift fork within the synchromesh clutch is to
1. lock the main drive gear and transmission main shaft
2. synchronize the speed of the mating parts before they engage
3. move the sliding gear and sliding sleeve forward as a unit
4. slide over the balls within the clutch and silently engage the external teeth on the main drive gear

8-13. The synchromesh transmission of textbook figure 9-8 engages the notches at the inner ends of the bell cranks by means of
1. shifter forks
2. a first speed clutch
3. poppets
4. a dog clutch

8-14. Some trucks are powered by the same-sized engines you find in passenger cars. Why do these trucks have a greater mechanical advantage than the passenger cars have?
1. Their engine-to-axle gear ratio is greater
2. Their engine-to-axle ratio is smaller
3. They are equipped with synchromesh transmissions

8-15. Which type of transmission, if any, will increase the mechanical advantage of a truck?
1. Constant-mesh main transmission
2. Auxiliary transmission
3. Synchromesh main transmission
4. None

8-16. Name the possible gear combinations in the constant-mesh auxiliary transmission of textbook figure 9-11?
1. Low drive and overdrive
2. Low drive and direct drive
3. Low drive, direct drive, and overdrive
4. Direct drive and overdrive

● Items 8-17 through 8-20 concern the auxiliary transmission of textbook figure 9-11, and are to be judged true or false.

8-17. When in direct range, the low speed main shaft gear runs free on the main shaft and meshes constantly with the countershaft low speed gear.

8-18. In direct drive low gear, the dog clutch engages the main-drive gear.

8-19. In direct drive high gear, the dog clutch is forward and connects the input shaft directly to the main shaft.

8-20. In low range, the transmission transmits power to the propeller shaft directly from the main transmission without a speed reduction.

Learning Objective: Describe techniques of troubleshooting automotive transmissions. Textbook pages 161 through 163.

8-21. Which of the following conditions produces torsional vibrations that sound like noises in the transmission?
1. Worn universal joints
2. Loose U-bolts
3. Unbalanced wheels
4. Each of the above

8-22. A warped friction disk that does NOT allow the clutch to fully disengage is a cause of
1. transmission noises
2. slipping out of gear
3. hard shifting into gear
4. no power to the propeller shaft

8-23. What effect does the lock-out mechanism in the transmission produce when it doesn't exert enough spring pressure on the gears?
1. Slipping out of gear
2. Hard shifting
3. Gear clashing, low to second gear
4. Gear clashing, second to high gear

8-24. A diagnosis of misalignment between the transmission and engine is checked by
1. removing the transmission and examining the clutch shaft
2. measuring flywheel wobble with a dial indicator
3. rotating the crankshaft rapidly and looking for variations in the housing bore
4. counting clutch-pedal pulsations

8-25. Which of the following conditions develops inside a transmission and results in power NOT being transmitted to the propeller shaft?
1. Slipping clutch
2. Misalignment between the transmission and engine
3. A sheared spline

8-26. Of the following conditions, which could cause the gear to clash when you are shifting into either second or high gear?
1. Excessive free travel of clutch pedal
2. Broken synchronizer spring
3. Gear sticking on the main shaft of the transmission
4. Each of the above

8-27. Which practice could result in transmission oil leaks?
1. Underfilling the transmission with oil of the right type
2. Maintaining the oil in the transmission at a level higher than recommended
3. Bolting the bearing retainer tightly to the transmission case
4. Tightening gently the filler plug of the transmission with a wrench

8-28. Assume you hear a noise coming from a vehicle. The vehicle is not moving, its engine is running, the clutch is engaged, and the transmission is in neutral. How should you go about deciding that the noise is coming from the transmission only?
1. Disengage the clutch, and find that the noise stops
2. Disengage the clutch, and find that the noise continues
3. Put the transmission in gear, and find that the noise continues

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Learning Objective: Explain operating principles and troubleshooting techniques for transfer cases. Textbook pages 163 through 165.

8-29. A transfer case enables the power to be divided or transferred to both forward and rear propeller shaft connections to drive vehicle wheels for additional traction.

8-30. In a 6-wheel drive vehicle, an extra propeller shaft connects the drive shaft of the transfer case to the rearmost axle assembly. The extra shaft is connected to the transfer case through
1. the transmission brake drum
2. the propeller shaft assembly and then to the live axles
3. direct connections between the input shaft and the main shaft

8-31. Whenever more traction is required of a 4-wheel truck, the front wheel drive is engaged automatically by a(n)
1. sprag unit
2. slip joint
3. two-way clutch
4. auxiliary transmission

8-32. Usually the first sign of trouble in a transfer case is
1. clutch slipping
2. gear clashing
3. shift lever vibration
4. noise

8-33. Which of the following conditions is likely to cause a noisy transfer case?
1. Worn or broken gears
2. Worn bearings
3. Excessive endplay in the propeller shaft
4. Each of the above

Learning Objective: Identify the types of power takeoffs and propeller shaft assemblies and their uses in automotive vehicle operation. Textbook pages 165 through 167.

8-34. In an automotive vehicle, which type of power takeoff unit usually transmits power to the auxiliary accessories?
1. Single-gear, two-speed
2. Two-gear, two-speed
3. Single-gear, single-speed
4. Two-gear, single-speed

8-35. The power takeoff units whose gear arrangements provide three or more forward speeds are used to operate
1. power trains
2. winches
3. tracklayers
4. front wheel drive

8-36. Which of the following units form the propeller shaft assembly that enables power to be transmitted between the transmission and live axles?
1. Propeller shaft, a slip joint, and one or more universal joints
2. Propeller shaft, two slip joints, and one or more universal joints
3. Propeller shaft, two slip joints, one or more universal joints, and a differential

8-37. Refer to textbook figure 9-15. Which of the following is a difference between (A) the torque tube drive and (B) the Hotchkiss drive?
1. In A, the propeller shaft is housed in a tube; in B, it is not
2. Universal joints are used in A, but not in B
3. Rear springs serve as torque members in A, but not in B

8-38. Which component in the power train of a moving vehicle adjusts to changes in the distance between the transmission and the axle assembly?
1. Universal joint
2. Slip joint
3. Driving axle

8-39. In a torque tube drive, universal joints connect the transmission to the propeller shaft.

Learning Objective: Explain fundamentals of automotive differentials. Textbook pages 167 through 169.

8-40. One purpose of the differential in the rear axle assembly of a wheeled vehicle is to
1. serve as a torque member
2. ensure that the rear wheels always turn at the same speed
3. boost engine power transmitted to the wheels
4. enable the axles to be driven as a single unit although turning at different speeds

8-41. Refer to textbook figure 9-18. Through which parts of the differential is power transmitted directly to the axle shafts?
1. Differential case and roller bearings
2. Bevel drive pinion and pinion bearings
3. Differential pinions and side gears
4. Pinion shaft and bevel drive gear

8-42. Which of the following parts rotate as a single unit with the drive gear when resistance is equal on each rear wheel of a vehicle?
1. Differential pinions
2. Side gears
3. Axle shafts
4. All the above

8-43. Compared to a standard differential, the high-traction differential for automotive vehicles conbines pinions and side gears that have
1. fewer teeth but the same tooth form
2. more teeth but the same tooth form
3. fewer teeth and a modified tooth form
4. more teeth and a modified tooth form

8-44. Which of the following are parts of the standard differential but not of the no-spin differential?
1. Ring gear and spider
2. Pinions and side gears
3. Two driven clutch members with side teeth
4. Spring retainer and trunnions

8-45. Which of the following is a differential noise?
1. Humming from a vehicle only when it turns a corner
2. Humming from a moving vehicle only when the clutch pedal is depressed
3. Humming from a vehicle only when it is driven on paved roads
4. Each of the above

Learning Objective: Indicate operating principles of axles, wheels, and tracks. Textbook pages 170 through 172.

8-46. Which of the following components carries part of the weight of a vehicle, but does NOT drive the wheels?
1. Live axle
2. Axle trunnion
3. Dead axle
4. Bogie drive

8-47. By which means is the rearmost axle of a 6-wheel drive vehicle joined to the third axle?
1. Propeller shaft
2. Torque rods
3. Live axle
4. Trunnion axle

In items 8-48 through 8-51, select from column B the type of axle that best fits the description in column A.

A. Descriptions	B. Types of Axles
8-48. The axle housing carries the weight of the vehicle because the wheels are supported by bearings on the outer ends of the housing	1. Plain live axle
8-49. Axle shafts are supported directly in bearings located in the center and ends of the axle housing	2. Semifloating axle
8-50. Each wheel is carried on the end of the axle tube on two ball bearings or roller bearings and the axle shafts are bolted to the wheel hub	3. Three-quarter floating axle
8-51. The wheels are keyed or bolted to outer ends of axle shafts and the outer bearings are between the shafts and housing	4. Full floating axle

8-52. What power train component is required to convert a military 6 x 4 truck to a 6 x 6?
1. Dead axle
2. Transfer case
3. Power takeoff
4. Live axle

8-53. The tracks on track-laying vehicles are driven in the same manner as wheels on wheeled vehicles except that the tracks are moved on rollers.

Learning Objective: Point out good and poor practices in servicing power trains. Textbook page 173.

8-54. At what level should the lubricant be maintained in the gear cases of vehicle power trains?
1. One inch below the inspection hole
2. Two inches below the inspection hole
3. Three inches below the inspection hole
4. Even with the bottom of the inspection hole

8-55. A mechanic should allow a vehicle to stand awhile on a level surface before checking the amount of lubricant in the gear case.

8-56. Which of the following practices could cause a clutch to slip?
1. Underfilling the transmission with oil
2. Filling the transmission with oil that is too light or too heavy
3. Overfilling the transmission with oil

8-57. When servicing the power train, why must the mechanic make sure the leather boot covering the universal and slip joints remains in place?
1. To improve the lubricating properties of grease
2. To prevent grease from being thrown from the joints
3. To keep the propeller shaft balanced
4. To prevent leaking seals

8-58. Which of the following conditions should mechanics look for when inspecting the power train of a vehicle?
1. Missing transmission bolts
2. Bent propeller shaft
3. Loose U-bolts
4. All the above

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